THE KENT INCORPORATED SOCIETY
FOR PROMOTING EXPERIMENTS IN
HORTICULTURE

ANNUAL REPORT

(TWENTY-FIRST YEAR)

1933

EAST MALLING
RESEARCH STATION
KENT

1st January, 1933, to 31st December, 1933

Published May, 1934

PRINTED IN GREAT BRITAIN BY HEADLEY BROTHERS
109 KINGSWAY, LONDON, W.C.2 ; AND ASHFORD, KENT

CONTENTS

PAGE

COMMITTEE 9

STAFF 10

EDITORIAL 12

SECTION I

THE EXPERIMENTAL FARM 13

SECTION II

GENERAL REVIEW OF RESEARCH WORK 27

SECTION III

PRELIMINARY RESEARCH REPORTS 59

POMOLOGY

Apple Manurial Trials. T. N. HOBLYN and W. A. BANE. Part I. The Renovation of Unmanured Trees. Part II. The Treatment of Trees under Grass 59

Root Studies. IV. A method of observing root growth in the field; illustrated by observations in an irrigated apple orchard in British Columbia. W. S. ROGERS 86

The Influence of Branch Pruning of Cherries on the Growth of Suckers. N. H. GRUBB and R. C. KNIGHT 92

The Testing of New Varieties of Apple Rootstock. A Progress Report. H. M. TYDEMAN 94

New Varieties of Rootstock for Plums. A Preliminary report on trials with seedlings of *Prunus divaricata*. H. M. TYDEMAN 100

POMOLOGY (*continued*)

PAGE

A Method of Converting Unprofitable Fruit Trees. R. J. GARNER 103

Plum Rootstocks—A Note on Some Root-systems. E. G. ING 108

Weather Conditions During 1933. H. C. CHAPELOW and H. M. TYDEMAN 111

PHYSIOLOGY

Further Observations on the Parts Played by Root and Stem in Stock Influence. R. C. KNIGHT 114

The Effect of Size of Tree on the Relations between various records of Roots and Stems of Apples. R. C. KNIGHT and T. N. HOBLYN 117

The Distribution of Growth between Roots, Stems and Leaves in a young apple tree and its possible bearing on the problem of stock effect on tree vigour. M. C. VYVYAN 122

See also Pomology.

HOPS

Cultural Trials with Hops. I. The Effect of Distance of Planting and Number of Bines per String—A Progress Report. F. H. BEARD .. 132

BIOCHEMISTRY

Tree Injection—A Progress Report. W. A. ROACH 137

See also Entomology.

MYCOLOGY AND BACTERIOLOGY

Notes on Plant Diseases in 1933. H. WORMALD 142

Bacterial Diseases of Stone Fruit Trees in Britain. V. Some Field Observations and Experiments on Plum Bacterial Canker. H. WORMALD 147

Strawberry Root Rot. G. H. BERKELEY 154

A Field Spraying Trial of Combined Fungicide-Contact Insecticide Sprays in 1933—A Progress Report. M. H. MOORE 156

Some Field Observations on Apple Canker (*Nectria galligena*). M. H. MOORE 166

ENTOMOLOGY

PAGE

Notes on Mite and Insect Pests for the Year 1933. A. M. MASSEE 176

Investigations on the Control of the Strawberry Tarsonemid Mite. A. M. MASSEE 181

Studies on *Byturus Tomentosus* Fabr. IV. 1933 Experiments on the Control of the Raspberry and Loganberry Beetle. W. STEER 188

Experiments on the Control of the Apple Sawfly (*Hoplocampa testudinea* Klug.) The results of one season's field trials and some considerations arising from them. G. L. HEY and W. STEER 197

An Experiment on the Control of the Apple Blossom Weevil (*Anthonomus pomorum* (L.) Curt.) by means of a Derris Dust. G. L. HEY, A. M. MASSEE and W. STEER 217

A Progress Report on the Causes of Immunity to the Apple Woolly Aphis (*Eriosoma lanigerum* Hausmann). R. M. GREENSLADE, A. M. MASSEE and W. A. ROACH 220

Some Notes on the Woolly Aphis Parasite (*Aphelinus mali* Hald.). R. M. GREENSLADE and A. M. MASSEE 225

Tortrix Investigations in 1933. G. L. HEY and A. M. MASSEE 228

Observations on the Effects of Various Gas Mixtures of Known Composition on Tortrix Larvae in Store. G. L. HEY and A. M. MASSEE 231

Miscellaneous Observations on Apple Sawfly (*Hoplocampa testudinea* Klug.) in 1933. G. L. HEY and W. STEER 234

SECTION IV

BULLETINS FOR FRUIT GROWERS 243

POMOLOGY

Scion Rooting at East Malling Research Station. R. G. HATTON and N. B. BAGENAL 243

A Note on the Training of Loganberries and Blackberries. A. B. BEAKBANE 247

MYCOLOGY

Brown Rot Fungi—Recent Observations on their Incidence. H. WORMALD 250

ENTOMOLOGY

PAGE

The Warm Water Treatment of Strawberry Plants. A. M. MASSEE .. 256

Apple Sawfly—Some Suggestions for Control Measures. G. L. HEY, M. H. MOORE and W. STEER 258

GENERAL

Some Recent Investigations into Methods of Storing Walnuts during the Winter. J. B. HAMOND 259

The Use of Rubber Strips in Budding Fruit Trees. R. J. GARNER 263

Other Publications of General Interest 264

PUBLICATIONS

List of Published Reports 265

APPOINTED MEMBERS OF THE SOCIETY

Appointed by the Ministry of Agriculture:

Sir F. W. KEEBLE, D.Sc., F.R.S., Hammels, Boar's Hill, Oxford.

Appointed by the Kent County Council:

Alderman F. W. PAYNE, C.A., Chairman K.C.C., Rose Bank, 55 Anerley Park, Anerley, S.E.20 (*ex-officio*).

Sir W. W. BERRY, K.B.E., C.A., J.P., Gushmere Court, nr. Faversham, Kent. (*Deceased, December*, 1933.)

G. E. CHAMPION, Esq., Linton, Maidstone, Kent. (*Deceased, November*, 1933.)

Sir O. E. d'AVIGDOR GOLDSMID, D.L., J.P., M.A., LL.B. (*Appointed, December*, 1933.)

W. J. THOMAS, Esq., Rodmersham. (*Appointed, February*, 1934.)

Appointed by the Surrey County Council:

S. S. BOORMAN, Esq., Send, Woking, Surrey.

Appointed by the East Sussex County Council:

E. S. ATTRELL, Esq., Warren Fruit Farm, North Common, Chailey, Sussex.

Appointed by the West Sussex County Council:

F. H. PADWICK, Esq., C.B.E., M.A., J.P., The Red House, West Ashling, Chichester. (*Retired, May*, 1933.)

W. R. BURRELL, Esq., Knepp Castle, Horsham. (*Appointed, May*, 1933.)

Appointed by the South-Eastern Agricultural College:

R. M. WILSON, Esq., B.Sc.Agric., Principal, The College, Wye, Kent.

E. HARDY, Esq., C.C., Boughton Court, Ashford, Kent.

Lord NORTHBOURNE, C.C., Northbourne Court, Deal, Kent.

Appointed by the Research and Advisory Committee, S.E.A. College, Wye:

Professor V. H. BLACKMAN, Sc.D., F.R.S., F.L.S., Imperial College, South Kensington, London, S.W.7.

Appointed by the Senate of the University of London:

Professor Dame HELEN GWYNNE-VAUGHAN, G.B.E., D.Sc., LL.D., F.L.S., 93 Bedford Court Mansions, London, W.C.1.

Representing the Long Ashton Horticultural Research Institution:

Professor B. T. P. BARKER, M.A. (Director), Long Ashton, nr. Bristol (*ex-officio*).

Representing the John Innes Horticultural Institution:

Sir DANIEL HALL, K.C.B., M.A., F.R.S., LL.D. (Director), Merton, Surrey (*ex-officio*).

Representing the Cambridge University Horticultural Research Station:

Sir R. H. BIFFEN, M.A., F.R.S., School of Agriculture, Cambridge (*ex-officio*).

Appointed by the National Farmers' Union (Kent Branch):

A. DAY, Esq., Great Tong Farm, Headcorn, Kent.
B. R. DIXON, Esq., Cambridge, Greenstreet, Sittingbourne, Kent.
W. T. EDMONDS, Esq., Allington Farm, Maidstone, Kent.
T. T. HARLOW, Esq., The Pines, Matfield, Kent.
T. D. HARRIS, Esq., C.C., Tudeley Hall, Tonbridge, Kent.
J. KITCHIN, Esq., J.P., Boughton Place, Sandway, Kent.
P. MANWARING, Esq., J.P., Crossway, Knole Paddock, Sevenoaks, Kent.
S. W. MOUNT, Esq., Hode Farm, Patrixbourne, Canterbury, Kent.
T. NEAME, Esq., The Offices, Macknade, Faversham, Kent.
J. A. RAYNHAM, Esq., Dairy Farm, Marden, Kent.
J. M. ROBERTSON, Esq., Beluncle, Hoo, Rochester, Kent.
W. ROGERS, Esq., The Court Lodge, Horton Kirby, Kent.

Appointed by the Horticultural Trades' Association:

L. J. COOK, Esq., Stuart Low & Co., Enfield, Middlesex.

Appointed by the Institute of Brewing:

H. G. YOUNGER, Esq., Research Department, Institute of Brewing, Brewers' Hall, Addle Street, London, E.C.2.

Honorary Members:

The Right Hon. Lord CORNWALLIS OF LINTON, C.B.E., T.D., D.L., C.A., J.P., Linton Park, Maidstone, Kent.

Professor E. S. SALMON, F.L.S., The Research and Advisory Section, The College, Wye, Kent (*ex-officio*).

JAMES STENHOUSE, Esq., A.C.G.I., *The President*, The Institute of Brewing, Brewers' Hall, Addle Street, London, E.C.2 (*ex-officio*).

H. V. TAYLOR, Esq., O.B.E., A.R.C.S., B.Sc., Ministry of Agriculture and Fisheries.

MEMBERS OF THE EXECUTIVE COMMITTEE

Prof. B. T. P. BARKER, M.A. (*ex-officio*).

Sir R. H. BIFFEN, M.A., F.R.S. (*ex-officio*).

Prof. V. H. BLACKMAN, Sc.D., F.R.S., F.L.S.

L. J. COOK, Esq.

A. DAY, Esq.

W. T. EDMONDS, Esq.

Sir DANIEL HALL, K.C.B., M.A., F.R.S., LL.D. (*ex-officio*).

R. G. HATTON, Esq., C.B.E., M.A., V.M.H. (Director).

P. MANWARING, Esq., J.P. (Chairman).

S. W. MOUNT, Esq. (Chairman Finance Sub-Committee and Vice-Chairman).

T. NEAME, Esq.

J. A. RAYNHAM, Esq.

J. M. ROBERTSON, Esq.

Professor Dame HELEN GWYNNE-VAUGHAN, G.B.E., D.Sc., LL.D., F.L.S.

R. M. WILSON, Esq., B.Sc.Agric.

H. G. YOUNGER, Esq.

Honorary Members:

The Right Hon. Lord CORNWALLIS OF LINTON, C.B.E., T.D., D.L., C.A., J.P., Linton Park, Maidstone, Kent.

Professor E. S. SALMON, F.L.S., The Research and Advisory Section, The College, Wye (*ex-officio*).

H. V. TAYLOR, Esq., O.B.E., A.R.C.S., B.Sc., Ministry of Agriculture and Fisheries, 10 Whitehall Place, London, S.W.1.

W. ROGERS, Esq., The Court Lodge, Horton Kirby, Kent.

Representative of Staff Council:

H. WORMALD, D.Sc. (Lond.), A.R.C.S., D.I.C.

STAFF

Director: RONALD G. HATTON, C.B.E., M.A. (Oxon), V.M.H.

Assistant Director: R. C. KNIGHT, D.Sc. (Lond.). D.I.C.

Technical Officer: N. B. BAGENAL, B.A. (Cantab.).

Pomology: R. G. HATTON,* C.B.E., M.A. (Oxon), V.M.H.
N. H. GRUBB, M.S.A. (Cornell).
W. S. ROGERS, M.A., Dip. Hort. (Cantab.).
J. AMOS, N.D.H., *Manager* Recorder.
R. J. GARNER, N.D.H., Dip. Hort. Sci. (Reading), *Propagator* and Recorder.
A. W. WITT, N.D.H., *Propagator* (Advisory).
H. M. TYDEMAN, Assistant Recorder, *Plant Breeding.*
A. C. PAINTER, *Assessor of Market Qualities.*
F. H. BEARD, Hort. Dip. (Wye), Assistant Recorder, *Hops.*
W. A. BANE, B.Sc.Hort. (Reading), *Soil Survey.*
D. H. HAMMOND, *Assistant Propagator.*
Miss A. B. BEAKBANE, B.Sc.Hort. (Lond.), N.D.H., Assistant Recorder.

Plant Physiology: R. C. KNIGHT,* D.Sc. (Lond.), D.I.C., of the Imperial College of Science and Technology.
M. C. VYVYAN, M.A. (Cantab.).
Lab. Assistant: P. HILLS.

Mycology and Bacteriology: H. WORMALD,* D.Sc. (Lond.), A.R.C.S., D.I.C.
R. V. HARRIS, B.Sc. (Lond.), A.R.C.S., D.I.C.
M. H. MOORE, Dip. Hort. Sci. (Reading), Special Assistant, *Spraying Trials.*
Miss J. B. HAMOND, B.Sc. (Lond.), Special Assistant, *Walnut* Propagation and Diseases.
Lab. Assistant: Miss K. CORNFORD.

Entomology: A. M. MASSEE,* F.R.E.S.
W. STEER, B.A. (Cantab.).
R. M. GREENSLADE, B.Sc., A.R.C.S.
Lab. Assistant: R. G. GAMBRILL.

Bio-Chemistry: W. A. ROACH,* B.Sc. (Lond.), A.R.C.S., D.I.C., A.I.C.
Lab. Assistant: O. USMAR.

Statistics: T. N. HOBLYN, Hort. Dip. (Wye).
Miss J. L. EDGAR, B.Sc. (Lond.).
Lab. Assistant: Miss J. S. PLACKETT.

* Recognized teacher of the University of London, for purposes of Higher Degrees.

Guide Demonstrator and Exhibitions Officer: H. C. CHAPELOW, Meteorological Records.

Advisory Officer in Commercial Fruit Growing to the Kent County Council stationed at East Malling, Kent: W. G. KENT, N.D.H.

ADMINISTRATION.

Secretary: C. T. ROYLE.

Book-keeper: P. R. WOOD.

Director's Personal Secretary: Miss L. E. ALEXANDER.

Clerical Staff: Miss I. M. FISHER, Miss M. E. DAY, Miss E. M. LAWSON, Miss J. M. COY and Miss J. BURGESS.

THE IMPERIAL BUREAU OF FRUIT PRODUCTION

is accommodated at East Malling Research Station.

STAFF.

Director: R. G. HATTON, C.B.E., M.A. (Oxon), V.M.H.

Chief Officer: D. AKENHEAD, M.A. (Oxon), B.Sc.Agric. (Lond.).

Assistant: G. St. C. FEILDEN, B.A. (Oxon).

Secretary: Miss R. M. ALLISTON.

Shorthand-Typist: Miss F. H. WHITEHEAD.

Telephone: Imperial Bureau of Fruit Production Aylesford 7188.

VISITORS

Visits may be paid to the Research Station on any week day *by appointment* (Saturday afternoon under exceptional circumstances only).

Passenger Station: East Malling Halt (Southern Railway).

Goods Station: Aylesford (Southern Railway).

Bus Services by the Maidstone and District Bus Co., every 20 minutes from Maidstone to East Malling Church.

Ditton Corner on the main London—Maidstone Road (with Red Lamp Danger Signal) is the turning to the Research Station for visitors coming by road.

Telephone: Research Station Aylesford 7229.

Telegrams: *Research, East Malling.*

EDITORIAL

THE Station's Annual Reports are now published in two parts—that dealing with the general development and activities, which is presented by the Executive Committee to the Annual General Meeting, is now printed as a Supplementary pamphlet mainly for the use of our Committee and Members. The Annual Report of research work is made up of four sections as follows :—

I. The Experimental Farm.
II. General Review of Research Work.
III. Preliminary Research Reports.
IV. Bulletins for Fruitgrowers.

Thus the two parts (I. General and II. Supplement) of the Annual Report previously issued will now be more or less merged into a single volume, and the details of administration and extension activities circulated separately to our Members as explained above.

Section I

THE EXPERIMENTAL FARM

By J. AMOS, F. H. BEARD, M. H. MOORE and A. C. PAINTER

with introduction by R. G. HATTON

Introductory.

In presenting the report on the general work of the farm for 1933, for the benefit of those of our readers who have lately become members, we are repeating the remarks which formed the introduction to this section of the report in 1931, which it is very necessary to bear in mind when considering the results obtained.

The total area of the Research Station is now approximately 120 acres (Great East Field 22 acres, Egham Field 40 acres, Church Fields 20 acres, Newgates Field 25 acres, and Upper Grub and Newgates Shaw 13 acres). In addition a further 18 acres of apples and plums have just been rented in Kiln Field. However, quite a considerable proportion of the area (approximately 10 acres) is occupied by buildings, approaches, innumerable headlands to comparatively small experimental plots and even to planted areas which can never be commercially productive (approximately 6 acres). In addition, many of the plantings (approximately 40 acres) are still quite young and are producing no returns. Again, varieties of problematical commercial value have frequently to be deliberately chosen for planting in order to study the very troubles for which the grower is seeking an explanation. Finally, even amongst the yielding areas there are inevitably the " control " plots, the unpruned, unsprayed, unmanured, etc., which bring down the standard of the whole. The picking and marketing is often complicated by the very large number of varieties grown and the small plots into which many of the trials are divided, e.g. strawberry and raspberry trials may consist of as many as 300 to 400 separate plots, each of which has to be picked and recorded separately, thus appreciably increasing the cost of picking and the amount of handling, which, in its turn, renders it difficult to get the fruit on to the market in the best condition.

Owing to all these experimental exigencies it is only on comparatively small areas that our own ideal routine of cultural and spraying methods can be carried out. We would ask our grower readers to bear all these foregoing facts in mind in judging the results on an experimental farm. East Malling must not be looked at as a farm mainly demonstrating how things should be done ; only too often the right ways can only be found out after eliminating a succession of wrong ones, and it yet remains for some Educational Authority to demonstrate on a commercial scale the combination of right findings of research and put them in their economic frame. This point of view is being emphasized because we believe that our annual report on the farm could profitably be developed in more detail than heretofore, provided it is realized that we are not claiming to tell the story of a commercial holding run on up-to-date lines, but merely to state in terms of market value some of the experiences gained from the sale of fruit from our experimental plots. (R.G.H.)

FARM REPORT

Cultural.

A spell of severe frosts was experienced during January which caused a cessation of ordinary farm operations with the exception of pruning and the grubbing of trees. Apart from this the weather was, although cold, open and fairly dry, which enabled winter spraying to be carried out under ideal conditions. The weather during February was again cold and dry with some snow showers towards the end of the month. Considerable rainy periods occurred during March in contrast to April, which was very low in rainfall. However, warm sunny conditions induced an early blossoming of all varieties of plums, cherries and apples, the full blossom period being at least two to three weeks earlier than in the previous year. Several severe frosts during this period caused much anxiety and considerable damage to the blossom. Both May and June were fairly dry with abundant sunshine. On the 19th and 22nd of the latter month severe hailstorms did serious and permanent damage to the hard fruit and also to hops. The continued hot and dry conditions during July caused a rush with picking of all soft fruits, most of which had to be picked by the middle of the month. Three inches of rain were recorded towards the end of the month, the major portion of which fell during heavy thunderstorms on the 21st and 24th. The tropical conditions experienced during August caused considerable wilting of all fruit trees and was accompanied in many cases by a heavy leaf drop. September was again a month of sunshine and high temperatures, but rain to the amount of 3½ inches fell during the month. The generally hot and dry conditions of the last three months had the effect of causing the fruit of both apples and plums to ripen prematurely, necessitating early and quick harvesting. Humid conditions during the latter end of September and also in October favoured the spread of Brown Rot and were responsible for a considerable loss in the boxes of apples, which, owing to lack of storage room, had to be left in the plantation. Attention is being given to storage accommodation and this will undoubtedly prove an asset both from the experimental point of view and also financially. The remaining months of the year were notably dry and open and conditions ideal for all farm operations.

Fresh Plantings, Grubbings, etc.

On Great East Field one of the rootstock trial plots consisting of Bramley's Seedling interplanted with Worcester Pearmain has been thinned. The Worcesters were removed in order to allow of full development of the Bramley's—especially those on the more vigorous stocks. One and a half acres on Egham Field, previously occupied by raspberry varieties, has been planted with two-year trees of Beauty of Bath, Cox's Orange, and Worcester Pearmain on No. 9 rootstock. These will be used to test the effect of applying nitrogen at various times and in varying amounts.

On Church Fields a plot of 6 acres of plums and cherries, previously undercropped with strawberries, has been replanted with our heaviest cropping Seedling Black Currant —Wellington's Triple X.

The stock of Royal Sovereign strawberries raised from a clone plant has been rapidly increased during the past year and it has been possible to plant out ½ acre of runners, from which it is hoped to raise sufficient plants for a large scale trial at the end of 1934. A further small planting has been made of dessert varieties of gooseberries, viz. White Lion, Leader, Leveller and Greengage. These will serve as a source of cuttings and also provide fruit for marketing, etc. Owing to the occurrence of " root rot " troubles on plants in the Newgates strawberry field during the past year an acre

has been planted with clean and " infected " runners, in order to study the effect upon growth and cropping. The remaining 2 acres of Lloyd George under manurial trials on the Newgates Field was grubbed as soon as the fruit was picked. The whole has been heavily manured, ploughed, and subsoiled, and planted up with the four main groups of black currants, viz. Baldwin, Goliath, French and Boskoop. The bushes have been set at varying distances in order to compare yields from close versus wide planting. These 2 acres have been further interplanted with strawberries. Practically the whole of Upper Grub Field is now planted up with stool beds and nursery trials. The layout of the latter has been so arranged that the trees can stop *in situ* for a period of years, thus enabling early records to be obtained. There will also be an economy on land, which is now no longer available for permanent and extensive planting.

The total acreage of the station has been added to by the renting of an adjoining 18 acres, consisting in the main of commercial varieties of apples and plums. Whilst it is intended to run this commercially, it will be available for spraying and similar trials that can be carried out on a commercial scale. No fruit from this plantation, however, figures in the returns for the year under review. (J.A.)

Marketing.

The recovery which occurred in 1932 in the prices of the various soft fruit crops was well maintained, fair to good returns being obtained for all kinds grown on the Station.

Plum prices on the other hand ruled low as a result of a somewhat heavy crop throughout the country.

There was also a plentiful supply of early and midseason apples. The situation with regard to these was greatly aggravated by the presence on the market of large quantities of boxed Australian and Tasmanian apples, mainly Sturmer Pippin. This fruit, thrown on to an unresponsive market and fetching as it did as little as 4s. a 40 lb. box and sometimes less, completely knocked the bottom out of the market. As a result the prices for both early cooking and dessert fruit were the worst experienced for many years.

The damage done to the crops by hail has already been referred to. There is no doubt that this had the effect of largely accentuating the already low prices ruling both for apples and for plums.

Prices wherever quoted are those obtained for the main crop, odd consignments at the commencement and end of the season not being taken into account.

Individual Crops.

Strawberries. (Area under cultivation—$4\frac{3}{4}$ acres in Newgates Field in their second year, rather more than $\frac{3}{4}$ acre of which had been deblossomed and used for runners. Five acres in Church Fields, 2 of which were in their fifth year, $1\frac{1}{2}$ in their fourth, and $1\frac{1}{2}$ in their third year. In addition a small plot in Egham Field, consisting of a strawberry clonal trial. The plantings consist entirely of Royal Sovereigns.)

The strawberries in Newgates Field gave their first crop. The early blossom, which usually produces the largest fruit, was badly frosted with a result that at first the fruit was somewhat on the small side. The quality, however, was mainly good and, except for jam fruit, prices were distinctly high. Picking commenced on 10th June. In all some 9 tons 8 cwts. were picked off this field, which, after allowing for the rows

used for runners, represents a yield of approximately $2\frac{1}{4}$ tons per acre. This was marketed as follows :

Under the National Mark Label.

" Extra Selected " in 1 lb. punnets—1,460 lbs. Price 9d. to 1s. 3d. a lb.
" Selected " in 3 lb. chips—4,000 lbs. Price 7d. to 10d. a lb.

Under Own Label.

" Selected " in 3 lb. chips—1,950 lbs. Price 6d. to 9d. a lb.
Small fruit in 6 lb. chips—4,230 lbs. Price $4\frac{1}{2}$d. to 6d. a lb.
Jam fruit in tubs—3,260 lbs. Price £20 to £24 a ton.
Ungraded in 3 lb. chips—7,000 lbs. Price 6d. to 8d. a lb.

The gross amount received was £585 or £62 a ton.

Hail was experienced some ten days after picking started. This both marked and splashed the fruit with soil to some extent, otherwise a larger proportion would have been marketed under the National Mark Scheme. As it was, though graded to that standard, it was thought better not to market subsequent consignments under that label.

Had it not been for the hail it is estimated that 50 per cent. of the fruit was of a sufficiently high standard to be marketed under the scheme.

The fruit from the 5 acres in Church Field was in marked contrast to that from Newgates and strikingly illustrates the differences in crop that may be expected from plantations in good and poor condition. This area, which was laid out for a strain, time of planting, and spraying trial, was in a very weak condition at the beginning of the year, and was only retained in order to obtain some final experimental records. Only some 36 cwts. of fruit was picked from this piece. It was, moreover, of poor quality and much of it extremely small. For the sake of comparison the marketing returns for this piece are also given.

Under the National Mark Label.

Selected in 3 lb. chips—620 lbs. Price 6d. to 10d.

Under Own Label.

Selected in 3 lb. chips—220 lbs. Price 5d. to 6d.
Small fruit in 6 lb. chips—1,180 lbs. Price 3d. to 6d.
Jam fruit in tubs—1,980 lbs. Price £20 to £24.

The gross amount received was £70 or £39 a ton for a yield of 7 cwts. to the acre. The percentage of fruit of National Mark standard was as low as 21.

Raspberries. (Area under cultivation—3 acres of nine-year-old Lloyd George in Newgates Field.)

These plantations, which have been used for manurial and spraying trials during the past six years and are now considerably past their best, gave a total yield of 6 tons 18 cwts. and a gross return of £275 or £40 a ton. Of this some 3,000 lbs. were marketed in 3 lb. chips, at prices ranging in the main between 5d. and 7d. a lb., but the great proportion of the fruit, viz. 12,450 lbs., was marketed in tubs, being only suitable for jam. This fetched from £35 to £40 a ton, prices being much the same as in the previous year.

Gooseberries. (Area under cultivation—2 acres in Egham Field interplanted between bush pear trees consisting of a variety collection of Careless, Freedom, Greengage, Gunner, Keepsake, Leader, Leveller, White Lion and Whitesmith, the bushes being from five to thirteen years old.)

As has been customary during the past few years, the fruit was left to ripen for dessert. The crop was again rather light, being somewhat cut by frost at time of blossoming, and in consequence no thinning was necessary. In all, apart from Whitesmith, a little over 3½ tons of fruit were picked, for which a return of approximately £120 gross was received or 3½d. a lb.

The fruit was graded and marketed as usual almost entirely in chip baskets, particulars of the quantities and prices being as follows :

Selected in 6 lb. chips (24 to 30 berries to the lb.)—1,200 lbs.
Price 3d. to 6d. a lb.
Grade 1 in 12 lb. chips (30 to 40 berries to the lb.)—2,450 lbs.
Price 2½d. to 5d. a lb.
Grade 2 in 12 lb. chips (40 to 50 berries to the lb.)—2,750 lbs.
Price 2½d. to 4d. a lb.
Grade 3 in 12 lb. chips and half-sieves (60 to 70 berries to the lb.)—1,500 lbs.
Price 2d. to 3d. a lb.
Smalls in half-sieves (80 to 100 berries to the lb.)—250 lbs.
Price 1½d. to 2d. a lb.

The yellow berries, such as Gunner, Leveller, and Leader, in all cases fetched 1d. to 1½d. a lb. more than the white ones with the exception of White Lion. This berry, ripening as it does late in the season and coming on to the market when most other varieties have finished, in our experience always commands a good price. At the same time it forms a big bush and crops well.

The Whitesmith yielded approximately 22 cwts. of fruit and brought in some £18 gross.

Red Currants. (Area under cultivation—about ¾ acre interplanted between bush apple trees and consisting of some twenty odd varieties from eight to ten years old. Also ¾ acre of three-year-old bushes, which is being used for a variety and cropping trial; this has not yet come into bearing. Both of these are in Egham Field.)

Red currants cropped well, giving a total yield of rather over 3 tons and a gross return of £111 or 4d. a lb., this being the same price as last year. The fruit was marketed in 6 lb. chips.

The larger fruited varieties in all cases sold best—this comment is made quite apart from any consideration of varietal yields.

Black Currants. (Area under cultivation—1 acre of six-year-old mixed varieties in Egham, 1 acre of new seedling crosses in Upper Grub, and 2 acres of one-year Baldwin and Wellington's Triple X in Newgates Field.)

With the grubbing of the 6 acres of eight-year Baldwins in Newgates, part of the varieties in Egham, and the " Big Bud " Spraying Trial Plot in Great East, there only remain at the moment some 2 acres of black currants in bearing. These suffered severely from frost and in consequence the crop was light, the 1 acre of variety trials in Egham yielding a little over 1 ton of fruit and the acre of Seedling crosses in Upper Grub ¾ ton.

Prices were evenly maintained throughout the season, ranging between 5d. and 7d. a lb. The gross return amounted to some £102 and the average price to just under 6d. a lb. As with red currants the fruit was marketed in 6 lb. chips.

Cherries. (Area of Acid Cherries under cultivation—·4 of an acre of ten to twelve year-old Morellos, planted at 12 by 12 feet, ½ acre of seven-year-old Morellos, ⅔ acre of six-year-old Kentish Red and ⅓ acre of Carnation and young Morellos, all at 15 by 15 ft. in Egham Field.)

The Morellos cropped well, yielding in all somewhat over 3 tons 3 cwts. The trees that had been dehorned in the Spring of the previous year had made good wood growth and gave a moderate crop of exceptionally large fruit, whilst that from the other trees, though naturally smaller, was also of good quality.

The fruit, which was quite hard and immature at the time, was badly marked by the hailstorms previously referred to. As it ripened, however, the damage did not show up nearly so much as might have been expected and it is doubtful whether it depreciated the value of the crop to any noticeable extent.

The fruit, which is allowed to become quite dark, but not over-ripe, before being picked, was roughly graded into two size grades and marketed in chip baskets as follows:

Selected in 6 lb. chips—4,900 lbs. Price 4d. to 6d. a lb.
Grade 1 in 12 lb. chips—1,740 lbs. Price 4d. to 5d.
Ungraded and Miscellaneous—430 lbs. Price 3d. to 5d.

The gross amount received totalled £146 or an average of 5d. a lb.

The crop of Kentish Red cherries amounted to 18 cwts. but was ruined by the hail storms which occurred in the same week that picking was commenced. As a consequence they only yielded some £17, a return of 2d. a lb., which hardly covered picking and marketing expenses.

The sweet cherries in the variety collection are beginning to come into bearing, but the yield from this source is still quite small. What few cherries there were suffered severely from hail and only some 6½ cwts. were fit to be marketed.

Plums. (Area under cultivation—3 acres of eleven-year and 2 acres of eight-year trees in Egham Field, 2½ acres of five-year trees in Church Field, and ½ acre of eighteen-year-old miscellaneous trees in Great East.)

The Plum crop was inclined to be patchy. Generally speaking whilst the early and mid-season varieties only gave fair to moderate yields some of the later varieties cropped well. The damson crop, after last year's light yield, was heavy. The total yield from all varieties amounted to some 25½ tons.

As stated earlier, plums suffered considerable damage from hail, as much as 26 per cent. of the Purple Egg, 18 per cent. of the Victorias and 12 per cent. of the Czars having definitely to be marketed as " Blemished " fruit for what it would fetch. A large proportion of the remainder was marked to some degree or other.

Some 6¼ tons or 25 per cent. of the crop was marketed under the National Mark Scheme as against 12 tons or 45 per cent. last year. This reduction is partly due to the hail damage and partly due to the fact that a larger proportion of the crop this year came from varieties not eligible for marketing under the Scheme.

Owing to plentiful supplies prices for early and mid-season fruit ruled low compared with those for the last two years. Early Rivers fetched from 3s. to 7s., Czars from 2s. to 4s. 6d., Purple Egg from 1s. 6d. to 3s., and Pershore Egg from 1s. to 3s. per half-sieve according to grade. Better quality Victorias in 12 lb. chips fetched from 2s. to 3s. a chip and the lower grades from 2s. 6d. to 4s. a half-sieve.

Whilst there was some improvement towards the end of the season, Damsons at one time were fetching as little as 1s. a half-sieve or well below the cost of picking and marketing.

Warwickshire Drooper again proved its value as a late variety, coming on the market as it does under our conditions well after such mid-season varieties as Victoria and Giant Prune are finished. This year marketing was spread over the period 7th to 26th September, which owing to the season was earlier than usual. The trees again

cropped well and good prices were obtained for the fruit, Selected and Grade 1 fetching 3s. to 5s. a 12 lb. chip and small grades 4s. to 7s. a half-sieve. The average price throughout the season including a quantity of blemished fruit, worked out at approximately 7s. a half-sieve.

The eleven-year-old Presidents in the Plum stock trial gave their first crop, averaging from some 210 lbs. per tree in the case of those on Pershore and Myrobolan B, to some 60 lbs. in the case of those on Brussels and Broad Leafed Mussel. Picked between 16th and 22nd September (again let it be said this is earlier than usual) they found a ready market. Most of the fruit was marketed in 12 lb. chips at prices ranging from 3s. 6d. to 5s. a chip, only the smaller fruit being put into half-sieves—this fetched from 5s. 6d. to 6s. 6d. Even drops after being cleaned up brought in from 3s. 6d. to 6s. 6d. a half-sieve. The average price throughout was 7s. 8d. per half-sieve of 24 lbs.

The total value of the crop from the seventy trees comprising this trial amounted to £162 gross, or a return of £2 6s. per tree. It now remains to be seen whether the trees having once come into bearing will continue to crop.

In spite of frost damage to the early blossom, the Myrobolan Plums (now reduced to twenty-three trees) the story of which has been unfolded in the last two reports, once more cropped well, averaging 136 lbs. per tree, the average price per lb. being 3·3d., and the gross return per tree £1 17s. 5d. These trees which are now thirteen years old have yielded the following returns since coming into cropping in 1928 :

Total average yield per tree since planting	596 lbs.
Gross average price per lb. highest	6d.
lowest	3·2d.
Gross return per tree since planting	£9 2s. 2d.
Average annual yield per tree since coming into bearing in 1928	£1 10s. 4d.

Gross receipts from all varieties amounted to £546, being an average of 4s. 7d. a half-sieve. Allowing 1s. 6d. as the average cost of picking and marketing 24 lbs. of fruit this represents a net return of approximately 3s. a half-sieve against 5s. 9d. the previous year.

Rather under half the crop was marketed in 12 lb. chips, half-sieves being used for the remainder.

Pears. (Area under cultivation—6¼ acres in Egham Field, 4 of which consist of a number of different varieties from seven to fourteen years of age. The other 2¼ acres are not yet in bearing.)

There was no great quantity of pears, the total crop, including dropped fruit, only amounting to some 205 bushels, 85 of which were Conference. Sales yielded £87 or 8s. 6d. a bushel.

Apples. (Area under cultivation—23 acres in Great East, Egham, and Church Fields, consisting of many different varieties. Main varieties Bramley's Seedling 2½ acres, Lane's 2⅔ acres, Worcesters 2 acres, mainly fourteen-year planted trees at 15 by 15 ft.)

Apples, like plums, were inclined to be patchy. The total crop amounted to approximately 4,900 bushels or slightly less than that of last year, of which a small quantity still remains to be marketed. When this has been done it is estimated that total receipts will be in the neighbourhood of £1,220, representing a gross return of 5s. a bushel.

Owing to the hail damage, which was particularly severe in the case of apples, and russeting, which again proved troublesome, the quality of the fruit from a marketing point of view was mainly poor.

For the first time since the introduction of the National Mark Scheme there was no fruit fit to be marketed as " Extra Fancy ", and much that would have been sent up as " Fancy " and " Domestic " had to be relegated to lower grades. In all only some 1,300 bushels were marketed under the Scheme as compared with 2,300 in 1932.

Of the main varieties, Lane's and Worcesters had very fair to good crops, whilst Bramley's, after last year's heavy yield, were light. The following were the varieties that gave the principal yields :

Lane's Prince Albert	1,350	bushels.
Worcester Pearmain	660	,,
Bramley's Seedling	600	,,
Grenadier	300	,,
Cox's Orange	190	,,

Except where experimental or other considerations rendered it undesirable, Gladstone, Early Victoria and Codlins generally, Grenadier, James Grieve, Lord Derby, Worcester Pearmain, Bismarck, Cox's Orange, Allington and Bramley's Seedling were thinned to singles, except in the case of some of the younger Grenadiers, which were left in doubles.

As stated previously, early and mid-season prices were low, and the fruit moved slowly. The highest prices touched for Gladstone and Beauty of Bath were 3s. and 5s. a half-sieve respectively, and 5s. a bushel for Early Victoria and Grenadier, but much of the fruit fetched well below these levels. The same remarks apply in the case of Derbys, Lanes, and other cooking varieties.

" Fancy " Worcesters in boxes and half-sieves made from 6s. to 8s. a bushel and " C " grade standard in half-sieves from 4s. 6d. to 7s. for $2\frac{1}{4}$ inch size and upwards. " Fancy " Cox's in late October were making 10s. to 12s. a half box.

The early season, however, had the effect of bringing the apples on to the market much earlier than usual. By early December there was a distinct shortage in Cox's and fruit that had been fetching 8s. to 12s. a half-sieve was soon commanding prices of 12s. to 17s. or more.

Similarly at the beginning of January, Bramley's were touching as high as 10s. and have remained about that level ever since. Lane's which had been selling at 2s. to 5s. a bushel sold at 4s. 6d. to 7s., and fruit that it had hardly paid to put into bags began to sell at 3s. to 4s. a bushel. Thus those that had been in a position to store their fruit were able to reap a considerable benefit from higher prices.

Miscellaneous. Owing to the clemency of the weather during the blossoming period the six seven-year Peregrine peach trees on the South wall of the packing shed set a full crop, producing in all some 1,100 fruits. The quality was good and the fruit sold well, bringing in over £23. (A.C.P.)

Hops.

Area under cultivation 9 acres—6 acres of Professor Salmon's seedlings and commercial varieties in Egham Field ; $2\frac{1}{4}$ acres of selected seedlings and $\frac{1}{2}$ acre of Fuggles in Church Field ; $\frac{1}{4}$ acre of commercial varieties in Upper Grub. About 2 acres are not yet in full cropping.

Dry conditions during April caused the hop " flea " to be somewhat troublesome, in consequence it was necessary to dust the hills with a Derris powder. Downy Mildew spikes were not numerous until the end of May. There was, however, a severe outbreak of " terminal spikes " from 24th May to 6th June, and at the latter date lateral spikes were also numerous. This outbreak was possibly caused by the fairly heavy rainfall during May (2·21 inches). A severe hail storm on 19th June swept across the gardens causing much damage to the bine ; in most cases the growing tips of both bines and laterals being cut off, and the leaves badly cut about. On account of this damage it was considered advisable to omit the first Bordeaux spraying (top wire stage). A quantity of new growth was produced in consequence of the hail damage, much of it being very low down on the bine. This new growth proved very susceptible to Downy Mildew infection, which was largely encouraged by the heavy rainfall in July (3·18 inches).

The hops were sprayed with Bordeaux mixture on 17th to 19th July and again from 31st July to 3rd August. About fifty very late varieties were given a third spraying on 17th or 18th August. There was no attack of Downy Mildew on the cones at picking time.

Aphis was not troublesome, but Red Spider was present to a certain extent in the Church Field garden.

A strong N.E. wind at the end of the first week in September caused much browning of the cones where our necessarily random picking had left the rows exposed.

Our yields were slightly lower than in 1932. The total growth amounted to over 5 tons, compared with nearly 6 tons in the previous year. At the time of writing complete returns are not available, but prices so far obtained range from £11 10s. per cwt. for certain mixed pockets, to £17 per cwt. for Canterbury Golding and the seedling Y86. The seedlings C9a, OV7, X35, OT31, and OO63 made £16 10s. per cwt. Four pockets of Fuggles fetched £15 10s. per cwt., and numerous seedlings have made £14 10s.

(F.H.B.)

Routine Spraying Programme.

In most cases, application of sprays was made by means of a new high-power outfit—a 10 h.p. Lister engine driving a three-throw pump, the whole (including two 100 gallon tanks) being mounted on a wheeled chassis.* Previously, a 2½ h.p. outfit had been used, but the new machine enabled the work to be done much more quickly than formerly because of the higher pressure available. This machine was operated from the headlands in conjunction with a movable system of overground steel mains. Rubber hoses in 90 ft. lengths were used off the steel-main system at the necessary intervals. These hoses carried 8 ft. lances and single nozzles fitted with No. 1 discs. The delivery pressure was kept at 300-400 lbs. per square inch, according to circumstances. There were usually eight men spraying.

In certain cases, especially where isolated or small spraying jobs had to be done, it was more convenient to use one of the following exceptions to the usual method: (*a*) a 2½ h.p. engine with pump (worked at 200-300 lbs. pressure) and movable overground steel mains. (*b*) a hand-pumped barrel machine developing about 200 lbs. pressure, with one lance (when spraying amongst bedded stocks, etc. in the nursery, it was a great advantage to mount this machine in a cart so that hose was not dragged over the plants). (*c*) knapsack machines, for very young trees.

The following detailed programme is not complete, but it would be confused by the inclusion of all spraying of the general nursery beds, the clonal races of strawberries,

* A note concerning this new plant appeared in the last Annual Report (1932), on page 13.

the nursery Walnuts (sprayed twice with Bordeaux mixture against Bacterial Blight), etc., which was carried out from time to time during the season as occasion demanded. In the general nursery (which contains many different kinds of fruit), aphis, capsid (*Lygus*) and caterpillar were the chief troubles ; here, nicotine (5-8 ozs.) and soft soap (4-6 lbs.) were applied on several occasions. When lead arsenate paste (4 lbs.) was incorporated, spray gelatine (1 lb.) was used instead of soap.

The Research Station reference number of the plots sprayed is given in the programme below, to ensure easy and rapid reference to the spray-treatment given to particular trees at different periods during the season.

The symbols used for the sprays are :

BM. Bordeaux mixture (made with hydrated lime).
LS. Lime-sulphur.
A. Lead arsenate paste.
N. Nicotine.
SS. Soft soap.
G. Spray gelatine.
S. Sulphur.

All sprays are referred to in quantity of concentrate used *per* 100 *gallons*.

Routine Spraying Programme, 1933.

Period.	Spray used.	Hosts.	Sprayed against.	Remarks.
		WINTER.		
6th-20th Jan.	Standard **Tar-Distillate** (5 gals.)	Apples, Plums, Cherries, Black and Red Currants, Gooseberries.	**Aphis** and **Sucker** on apples. **Aphis** on other hosts.	All plots. Pears omitted (though sprayed in former years) owing to the absence of Aphis. Strength of spray 5 per cent. because (a) trees very "clean"; (b) spraying done in ideal conditions; (c) anticipation of liberal use of nicotine later for other pests (Capsid, Sawfly, etc.).
20th Jan.	Standard **Tar-Distillate** (10 gals.)	Apples.	**Aphis, Sucker** and **Caterpillar** (especially **Tortrix**).	On two plots (12 and 14) of Bramley and Worcester. Tortrix had been severe here. Some control obtained, but doubtful whether sufficient to justify extra expense.
28th Feb.	Standard **Tar-Distillate** (5 gals.)	Apples.	**Aphis** and **Sucker.**	Bramley's on one plot (12). Late spraying as trees were to have been grubbed, but decision later amended.
7th and 25th Mar.	**LS.** (3⅓ gals.)	Outdoor trained Peaches.	**Leaf-Curl** (*Taphrina deformans*).	Earlier spraying on peaches planted at Ditton Labs. Later spraying on those on Plot 18.
8th Mar.	**Winter Petroleum** (7 gals.)	Apples.	**Capsid** (*Plesiocoris rugicollis*).	On certain varieties on three different plots (2, 3 and 4).
		SPRING AND SUMMER.		
30th Mar.-4th April	**LS.** (3⅓ gals.) + **A.** (4 lbs.)	Pears (*green-bud*). Gooseberries (*pre-blossom*).	**Scab** and **Caterpillar.** **Mildew** and **Caterpillar.**	Plots 8 (cordons), 20, 36 (Plot 21 not sprayed because interplanted plums were in full bloom). Gooseberries underneath pears on Plot 36.
30th Mar.-3rd April	**LS.** (8½ gals.)	Black Currants.	**Big-bud Mite.**	Plots N2, N5, C5a, 17, 18, 29, 35. "Edina" group included because interplanted and randomized. Caused yellowing of leaves of varieties in this group.
4th April	**N.** (6 ozs.) + **SS.** (4 lbs.)	Plums and Cherries.	**Aphis.**	Plot 2.
7th-10th April	**LS.** (3⅓ gals.)	Pears (*white-bud*).	**Scab.**	Plots 20, 21, 36, C3. Arsenate omitted from this second pre-blossom spray because of gooseberries underneath pears (Plot 36), or of plums interplanted (Plot 21). Arsenate (4 lbs.) included on one plot (C3—no undercrops, apples interplanted).

Period	Spray used.	Hosts.	Sprayed against	Remarks.
8th-15th April	**LS.** (3⅛ gals.) + **A.** (4 lbs.)	Apples (*pink bud*)	Scab and Caterpillar.	Except Stirling Castle Plots 3, 4, 8 (cordons), 12, 13, 14, 16, 24, 30, 31, 33, 34, C2, starting with earliest flowering varieties. See below (15th-18th and 19th April) for exceptions to this treatment.
12th April	**BM.** (8 lbs. bluestone + 12 lbs. hyd. lime) + **A.** (4 lbs.)	Quince.	**Leaf-spot** (*Fabraea maculata*) and **Caterpillar.**	Plot 2.
12th April	**N.** (8 ozs.) + **SS.** (8 lbs.)	Young Pears and Red Currants.	**Capsid** (*Lygus pabulinus*)	Plot 27.
15th April	**BM.** (8 lbs. bluestone + 12 lbs. hyd. lime) + **N.** (8 ozs.) + **G.** (1 lb.)	Apples (*pink bud*).	**Scab, Capsid** (*P. rugicollis*) and **Caterpillar.**	On two plots (10 and 11). BM. used pre-blossom in preference to LS. because Lane's present, and this rendered BM. necessary *post-blossom* (Lane's are sulphur-shy post-blossom) on interplanted varieties on account of the spray-drift problem. Arsenate omitted as it was hoped to kill young caterpillars with the nicotine used primarily against Capsid.
18th-19th April	**BM.** (8 lbs. bluestone + 12 lbs. hyd. lime) + **A.** (4 lbs.)	Apples (*pink bud*).	Scab and Caterpillar.	On one plot (C3) where Lane's interplanted with Allington, Newton and Pears. Capsid not present.
26th April	**N.** (6 ozs.) + **SS.** (4 lbs.)	Outdoor trained Peaches.	Aphis.	On those planted at Ditton Labs.
3rd May	**BM.** (8 lbs. bluestone + 12 lbs. hyd. lime)	Pears (*petal-fall*).	Scab.	Plots 20, 21, 36. Conference not sprayed because Scab resistant. Arsenate omitted for reasons given above (see 7th-10th April).
6th-8th May	**N.** (8 ozs.) + **SS.** (8 lbs.)	Young Apples, Pears, Black and Red Currants.	**Capsid** (*L. pabulinus*).	Plots 27, 29, C5.
12th-17th May	**LS.** (1 gal.) + **A.** (4 lbs.)	Apples (*petal-fall*).	Scab and Caterpillar.	Plots 3, 4, 8 (cordons), 12, 13, 14, 16, 30, 31, 33, 34, C2. Omitting sulphur-shy varieties: Stirling Castle, Lane's, Beauty of Bath, Belle de Boskoop, Rival, St. Cecilia. Omitting also Scab-resistant varieties: Grenadier, Gladstone, Early Victoria, Lord Derby, Norfolk Beauty.
15th May	**N.** (8 ozs.) + **SS.** (8 lbs.)	Stirling Castle Apples, Red Currants.	**Capsid** (*L. pabulinus*).	Plots 32, 33, 34.

Period.	Spray used.	Hosts.	Sprayed against.	Remarks.
16th May	**BM.** (8 lbs. bluestone + 12 lbs. hyd. lime) **A.** (4 lbs.)	Apples and Pears (*petal-fall*).	**Scab** and **Caterpillar.**	Plots 4, 10, C3. Spraying of pears delayed on Plot C3 because interplanted with apples. BM. used on these apples (Bramley, Allington and Newton) because Lane's interplanted. (See 15th, 18th and 19th April).
19th-20th May	**N.** (8 ozs.) + **SS.** (8 lbs.)	Apples (about a week *post-petal-fall*).	**Sawfly.**	Worcester on Plots 12 and 14. (Not necessary on Bramley's.) Plots 30, 31, 33, 34. Certain plots omitted because Sawfly not prevalent or on account of experimental spraying.
22nd May	**LS.** (⅔ gal.) + **N.** (8 ozs.) + **G.** (1 lb.)	Apples (ten days *post-petal-fall*).	**Scab** and **Sawfly.**	On one Plot (16) only, already sprayed—on 12th May, when rain fell before the deposit was dry. Lane's again omitted.
22nd May	**N.** (8 ozs.) + **SS.** (8 lbs.)	Young Apples, Pears and Red Currants.	**Capsid** (*P. rugicollis*) on Apples; *L. pabulinus* on Pears and Reds.	Apples on Plot C2. Pears and Red Currants on Plot 27.
24th May	**N.** (6 ozs.) + **SS.** (5 lbs.)	Pears trained on buildings.	**Aphis.**	
25th May	**N.** (8 ozs.) + **SS.** (8 lbs.)	Apples and Pears.	**Sawfly.**	Apples and Pears on Plot C3. Grenadier and Lane's on Plot 11. These plots were not similarly sprayed on 19th-20th May because there then appeared to be little Sawfly present.
29th May	**BM.** (8 lbs. bluestone + 12 lbs. hyd. lime) **A.** (4 lbs.)	Quinces.	**Leaf-spot** and **Caterpillar.**	Plot 2.
29th May	Proprietary **S.** dust.	Strawberries.	**Mildew.**	Plot N3. Strawberries partially in flower.
31st May	**N.** (8 ozs.) + **SS.** (8 lbs.)	Apples.	**Capsid** (*P. rugicollis.*)	Plot 4 only. On Allington and Beauty of Bath acting as "buffers" for trees experimentally sprayed.
1st June et seq.	**LS.** (1 gal.)	Apples (*second post-blossom*).	**Scab.**	Plots 3, 4, 8 (cordons), 12, 13, 14, 16, 30, 31, 33, 34, C2. Arsenate (4 lbs.) included on certain plots (12, 13, 14, 16, C2) for better Scab-control. Nicotine (6 ozs.) given where necessary (Plots 8, 12, 13, 14, C2) for Aphis. Certain varieties omitted as at petal-fall (see 12th-17th May).
1st June	**BM.** (8 lbs. bluestone 12 lbs. hyd. lime)	Apples (*second post-blossom*).	**Scab.**	Plots 4, 10, C3—those varieties already sprayed post-blossom with BM. (see 16th May). Pears not sprayed because this not necessary.

Period.	Spray used.	Hosts.	Sprayed against.	Remarks.
16th-17th June	Proprietary **Derris** powder (2 lbs.) + **SS.** (5 lbs.)	Raspberries.	**Beetle** (*Byturus tomentosus*).	Plots 28, 29, N2.
29th-30th June	**N.** (6 ozs.) +**SS.** (4 lbs.)	Hops and Young Apples.	**Aphis.**	Hops on Plots 17, 26, 27, C5. Young apples on Plot C2 sprayed only where necessary (certain infested trees).
3rd July	**LS.** (1 gal.) +**G.** (1 lb.)	Plums.	**Red Spider.**	Plot 21. About 300 trees sprayed. Then spraying discontinued because of danger of leaving unsightly deposit on fruit. The most badly attacked trees remaining (Czars, Early Rivers) were dusted with a proprietary Sulphur dust.
6th July	**N.** (6 ozs.) +**SS.** (5 lbs.)	Young Apples.	**Aphis.**	Plot C2 (all trees, see 29th-30th June).
17th-20th July	**BM.** (10 lbs. bluestone + 15 lbs. hyd. lime) **N.** (6 ozs.)	Hops (just *pre-burr*).	**Downy Mildew** (*Pseudoperonospora Humuli*), and **Aphis.**	Plots 17, 26, 27, C5, N5. The first Bordeaux spray for "Downy" (usually applied when Hops have reached top wire) was omitted this year because of severe hail-damage to the leaves.
31st July-3rd Aug.	**BM.** (10 lbs. bluestone + 15 lbs. hyd. lime) **N.** (6 ozs.)	Hops (just *post-burr*).	**Downy Mildew** and **Aphis.**	Plots 26, 27, C5.
8th-9th Aug.	**BM.** (10 lbs. bluestone + 15 lbs. hyd. lime) **N.** (6 ozs.)	Nursery Hops only.	**Downy Mildew** and **Aphis.**	Plots 17, N5.
8th-11th Aug.	**Flowers of S.**	Hops.	"**Red Mould**" (*Sphaerotheca Humuli*).	Plots 26, 27, C5. About 36 lbs. dust per acre, applied from alternate alleys.
14th Aug.	**LS.** (1 gal.) +**N.** (6 ozs.) + **G.** (1 lb.)	Strawberries.	**Mites** and **Aphis.**	Plot N3.
17th Aug.	**BM.** (10 lbs. bluestone + 15 lbs. hyd. lime) **N.** (6 ozs.)	Hops (very late varieties—just *post-burr*).	**Downy Mildew** and **Aphis.**	Plots 26, 27, C5.
22nd Aug.	**Flowers of S.**	Hops.	"**Red Mould.**"	Plots 26, 27, C5. About 36 lbs. dust per acre, applied, on this occasion, from the other alternate alleys. (See above, 8th-11th Aug.)

Lane's were badly russeted where Bordeaux mixture was used pre-blossom (Plots 10, 11, C3). Many varieties (on Plots 30, 31, 33, 34) were badly russeted where nicotine and soft soap were used about a week after petal-fall for Sawfly-control, following a petal-fall application of lime-sulphur with lead arsenate for Scab and Caterpillar. One possible explanation for this russeting is that the skin of the young fruitlets was "scorched" by "free arsenic". The liberation of this would result from chemical reaction taking place, after spraying, between the soft soap and the lead arsenate (or its derivatives).

In contrast to our former custom, gelatine was omitted from the general routine programme of sprays, because its use with lime-sulphur against *Scab* was not considered necessary. (M.H.M.)

Section II

GENERAL REVIEW OF RESEARCH WORK

POMOLOGY

In Relation to Tree Fruits

(*a*) ROOTSTOCK INVESTIGATIONS.

APPLES.

As was foreshadowed in last year's report one of the rootstock trial plots consisting of Bramley's Seedling interplanted with Worcester Pearmain has been thinned. The Worcesters were removed in order to allow of full development of the Bramleys—especially those on the more vigorous stocks. One hundred and twenty-five trees were carefully lifted and provided a unique opportunity of securing root, stem and branch weights as well as detailed records of the thirteen-year-old root systems of some sixteen varieties of " Paradise " rootstocks, stem worked with a single scion variety. During the examination of this material only one tree was found to have " scion rooted ". The dangers of trees " scion rooting " especially on Jaune de Metz (No. IX) rootstock when the " union " is planted at or below ground level was recorded in a bulletin (Eg4).

The complete records of the original apple rootstock trials have now been examined to the end of the first thirteen-year period in readiness for publication. These show that as the years pass rootstock influence becomes accentuated, but that the reactions of cropping upon " vigour " are now suggesting the need for some qualifications of the original method of grouping.

The different responses of trees upon different rootstocks to grassing and manurial treatments is dealt with fully in two reports in Section III of this publication. The practical use to which a knowledge of rootstock influence can be put has been elaborated in a paper now in the press. (R.G.H. and J.A.)

ANALYSIS OF ROOTSTOCK INFLUENCE, INCLUDING THE RECIPROCAL EFFECT OF SCION UPON ROOT.

The series of Lane's Prince Albert trees, stem worked and root worked on vegetatively raised rootstocks and upon seedling roots, has made good growth this season, and records on comparative vigour of growth and axillary fruit bud formation should soon be available. (R.G.H. and J.A.)

The microscopical examination of the stock stems and roots of a further set of bench grafted Lane's Prince Albert apple trees worked on Nos. II, IX, XII and seedlings, has confirmed the results previously obtained and, in addition, has given some new information on the comparative anatomy of stems and roots above and below ground level. A third set of trees has been lifted and sections prepared for the final examination of this series of trees. (A.B.B. and B.C.)

PEARS.

A full account has been published of the work begun in 1917 upon the " Free " or Seedling Rootstocks for Pears (E66). Their description, selection, vegetative propagation and preliminary testing—showing a considerable range of difference in vigour, early blossom formation, as well as definite cases of incompatibility—has been dealt with.

The lifting of a large series of pear varieties worked upon different varieties of Quince and Pear Seedlings has brought into prominence the question of " scion rooting ", and offered material for study in considerable detail. " Incompatible " stocks readily induce the habit, and varieties of pear, known to be partially incompatible with quince, scion rooted fairly readily. In both cases, trees of peculiar habit of growth with little blossom resulted. These " passenger " trees are apparently very common in commercial pear plantations, and a popular bulletin was issued (Eg4) warning growers of the dangers of scion rooting. (R.G.H. and J.A.)

PLUMS.

Some 350 thirteen-year-old plum trees, which formed the original rootstock trial of ten widely different varieties upon seven different types of stock had to be removed to allow for the development of interplanted pear experiments. Full advantage was taken of this grubbing which allowed the taking of total tree weights as well as detailed observations upon the root systems. During the year all the data have been analysed for writing up a further report upon the influence of different rootstocks upon plum varieties, and of the behaviour of ungrafted plum trees upon their own roots.

(R.G.H. and J.A.)

PEACHES.

For a further season the trained trees of Hale's Early planted against a board fence failed to set a crop. Under these conditions particularly favourable weather conditions appear to be required for the setting of the fruit.

The clonal races of common peach have not so far been sufficiently well rooted on the layers to permit the planting of a series for budding. Further attempts will be made to improve rooting on the layers. (R.J.G. and A.W.W.)

CHERRIES.

(i) *Acid Cherry* (*Prunus cerasus*) *scions.*

A report on cherry rootstocks, and their influence on the Morello scion, appears in the *Journal of Pomology and Horticultural Science* (E64).

(N.H.G.)

(ii) *Sweet Cherry* (*P. avium*) *scions.*

Owing to the death and injury of a number of trees in the rootstock trials with Sweet Cherry scions from bacterial die back, the records so far collected are being examined statistically, to ascertain how far the trial is still likely to be of value.

(N.H.G.)

PROPAGATION.

The search for new rootstocks continues and intensive nursery trials of new apple and plum stocks have been planted together with existing commercial varieties.

Two hundred and eighty-eight new seedling apples, one hundred and seventy-nine of which were raised at the John Innes Horticultural Institution and one hundred and nine at East Malling from crosses between the variety Northern Spy and the stocks Nos. I, II and XII, after proving immune to the attacks of Woolly Aphis under greenhouse conditions, have been planted out for propagation tests.

The thirty groups of seedling prunus, presented by the John Innes Institution in 1931 and collected from the Caucasus, which were budded with the variety Czar in 1932, have all produced excellent maiden trees and so far no sign of incompatibility is apparent amongst any of the groups. The maiden trees will be retained for a further year in the nursery before any attempt will be made at vegetative propagation for further trial.

The three varieties of apple " stem-builders " obtained from Germany and budded in 1931 upon seedling apple, No. IX and No. XII rootstocks have been run up for a further season. Many of the trees on No. XII exceeded a height of ten feet at the end of the second year whilst the majority of the trees on No. IX were less than seven feet in height and these last have grown in a curve away from the perpendicular. All the trees will be grafted this Spring at standard height with single scions of commercial English varieties.

Eight thirteen-year-old trees of Stirling Castle have been " porcupine " grafted with Worcester Pearmain with striking success and a preliminary report appears on page 103, Section III. This method of " overworking " as previously used in Tasmania, should prove a ready means of changing over unsuitable varieties to those which are more remunerative.

The preparation of a series of plum trees having framework of a variety resistant to bacterial canker has been continued. The trees budded in July, 1932, have made excellent growth in their maiden year.

The series of nursery technique trials inaugurated in the Spring of 1932 has been extended to include nursery staking trials. It would appear that rubber budding-strips are at least as useful for tying purposes as raffia and may prove to be preferable in regard to absence of the risk of constriction from the region of the inserted bud. A note to this effect was published during the year (Eg6). So far the presence or absence of wood in the bud shield of apples appears to matter little as regards the resulting stand of trees in the nursery. A preliminary survey of the technique trials already undertaken will shortly be published.

The experiments on the propagation of fruit tree rootstocks by means of hardwood cuttings and root cuttings have been continued in collaboration with the Physiology section. Root cuttings of two selected free pear stocks graded into two length and three diameter grades have been planted to test the practical possibility of raising pear root-stocks by this method. (R.J.G.)

(*b*) ROOT DEVELOPMENT INVESTIGATIONS.

The observation of growing roots in the orchard, by means of observation trenches with glass windows fixed against the soil has been continued. Weekly records of period, amount and position of new root growth have been obtained on mature apple trees on three different rootstocks. Records have also been obtained of the "suberization" of the roots. Some idea of the length of time during which a particular rootlet absorbs in one spot has thus been obtained. As the records extend over three years in one trench and two years in three others, it is now possible to note how some roots remain, thicken and produce lateral roots in later years, while others—particularly the fine laterals—die, shrivel up and disappear through the action of insects and soil organisms.

Records of soil temperature and moisture have been correlated with the root growth. These records suggest that the root growth varies directly with the soil temperature so long as soil moisture is sufficient. A deficiency of soil moisture is reflected very rapidly in lessening of root growth. A preliminary report on this technique appears in Section III, page 86.

To determine the exact effect of light on the roots a special trial was carried out with root boxes having twelve observation windows subjected to various light conditions ranging from full daylight to complete darkness, with two intermediate conditions of periodical exposure. This has shown that roots will grow in full daylight, though they are severely checked thereby. Short intermittent exposures check the roots much less, though there is an indication that slight checking may occur.

Some new studies on the growth of strawberry roots in " observation boxes " are of particular interest in connection with the strawberry root rot which the Pathology Section is investigating. A technique is being developed by which the growth of healthy and diseased roots can be watched.

Several of the soil moisture meters developed here in connection with the root studies have been in operation throughout the season, and have given very interesting information concerning loss of water from the soil by evaporation and through absorption by tree and grass roots. The progress report on this instrument has been held up for the inclusion of these results.

Tree Excavations.

The root systems of two mature plum trees on Myrobolan stock were excavated in detail by the " block " method. It was found that although the main roots were shallow there were vertical roots descending to the rock, reaching a maximum depth of 7 ft. 6 ins.

Two pear trees interplanted with the plum trees were also excavated. (W.S.R.)

(*c*) INVESTIGATIONS IN BIENNIAL BEARING.

These have been continued and the data obtained are being examined with a view to a preliminary report. (A.C.P. and N.H.G.)

(*d*) DOUBLE WORKING OF FRUIT TREES.

Further data on the influence of intermediate scions on the cropping and fruit quality of apples have been collected.

The crop of pears was too light and irregular in 1933 to yield data of much value.

The nursery trial of double worked pears has made satisfactory growth in the first year since planting. (N.H.G.)

(*e*) INVESTIGATIONS INTO THE NON-SETTING OF THE BLOSSOM OF CERTAIN VARIETIES OF PEARS.

Stem ringing, carried out on certain trees of Pitmaston Duchess in Spring, 1932, definitely increased the number of axillary fruit buds which blossomed in 1933, but does not appear to have affected the number of terminal and spur fruit buds. The set of fruit in 1933 was very light throughout, and does not appear to have been noticeably increased by ringing.

The dehorned and top-grafted trees of Doyenne du Comice produced in 1933 very little blossom and scarcely any fruit.

Whilst the crop of Marie Louise was much lighter than that of 1932, the spur thinned trees again produced a slightly smaller number of fruits than unthinned trees; their fruit was 16 per cent. larger, and approximately of equal total weight to that of unthinned trees. The "set" of blossom was more than twice as great on the thinned as on the unthinned trees.

The experiment on the effect of three different methods of pruning on growth and cropping is being continued. The trees have now completed their second year's growth as single oblique cordons. Two varieties, William's Bon Chretien and Laxton's Superb bore a few fruits. (N.H.G., N.B.B. and H.M.T.)

(*f*) PRUNING.

Apples.

Winter spur thinning has again increased fruit size, sometimes at the cost of a small reduction in crop. The method of spur thinning seems largely immaterial; when applied to trees bearing large numbers of fruit buds, any reduction in the number of fruit buds results in larger fruit. Two years' work, however, has shown that large, well developed fruit buds produce more and larger fruits than small buds, even after allowing for the failure of some of the latter to blossom.

Dehorning has very considerably reduced the crop of *Lord Derby* and *Bismark*, but markedly increased the size of the fruit. Trees of Lord Derby dehorned two or three weeks before blossoming in 1933 showed distinctly more leaf scorch than similar trees dehorned one year earlier. (N.H.G.)

Pears.

The older series of pears under differential winter pruning treatments, have now had the plums with which they were interplanted removed. These new conditions will allow of full development of the trees, and the effect will be studied in relation to the pruning and its influence on the setting and quality of the fruit. The sets of trees that have hitherto been left unpruned are now being thinned and spur pruned. The commencement of further pruning trials on a younger series of trees has been held over for a further season and the trees have again been comparably pruned in order to ensure an adequate framework. (J.A.)

Cherries.

The Morellos dehorned in March, 1932, bore a moderate crop in 1933, their fruit was very much larger than that of any comparable trees not dehorned. It is proposed to dehorn the remaining trees in the older Morello plot in the Winter of 1933-34.

(*g*) FRUIT THINNING.

Plums.

A light crop again prevented any further experiments being done in this connection.

Apples.

The experiments previously referred to have been continued, and the results obtained in the case of the dessert varieties are now being analysed. (A.C.P.)

(*h*) MANURING.

APPLES.

The apple manurial trials in progress can be grouped under three headings :

(i) The Renovation of Unmanured Trees.
(ii) The Treatment of Trees in Grass.
(iii) The Treatment of Young Trees from Planting.

In the first two groups the trials have been carried out on trees of Bramley's Seedling and Worcester Pearmain worked on a wide range of " Paradise " rootstocks and now fourteen years old. In the third group the trial is more extensive and consists of Cox's Orange Pippin and Beauty of Bath on four representative rootstocks.

(i) *The Renovation of Unmanured Trees.*

Growth on the plots receiving potash alone and with nitrogen, was again good and though there was a considerable amount of leaf scorch this trouble was probably accentuated by the very dry and hot Summer. The reduction in amount effected by the potash was shown by the much greater severity on the Nil and Nitrogen only plots.

From the point of view of growth the dressings of potash can be said to have achieved their object in three seasons on trees which had previously been starved for ten years, and were consequently in a very bad condition.

As, however, the trees of Bramley's Seedling have had only one " bearing " year during this period the trial is being continued for another season to obtain further data on the effect on crop. At the same time it will show whether the quality of the fruit is adversely affected in any way by such heavy dressings of potash, a point on which very little information is available. While the crop of 1933 was very light, striking differences in the comparative maturity of fruit from the different treatments were evident and with promise of a full crop in 1934 it is hoped that more complete results will be obtained.

While in the main the two varieties on various rootstocks have responded in the same way to the different treatments there are some very interesting exceptions, mostly due to the influence of rootstock.

A Progress Report is included in Section III of this Report.

(ii) *The Treatment of Trees in Grass.*

The trials have taken place on two plots on which the objects, as determined by the conditions, were quite distinct. On one, consisting of Bramley's Seedling and Worcester Pearmain interplanted at 15 feet square, grass had been sown in the Spring of 1930 and with the exception of $1\frac{1}{2}$ cwt. per acre of sulphate of ammonia in July of that year the plantation had received no nitrogenous manuring from that time to the late Winter of 1932-33, when the first dressing of nitro-chalk was given. Symptoms of nitrogen starvation were by this time very marked and consequently it was decided to test the effect of an extreme dressing of 15 cwt. against the more usual one of 5 cwt.

On the second plot, from which the interplanted trees of Worcester Pearmain had just been grubbed, the lack of nitrogen was not yet acute as the grass had been sown only a year before. The aim here was therefore to prevent the starving effect of the grass and consequently 5 cwt. per acre of nitro-chalk was applied to the Bramley's Seedling, comparable trees being left unmanured.

The results in the case of Worcester Pearmain were very definite. The difference in fruit colour was very striking, while there were also marked contrasts in firmness of fruit and condition of foliage.

With Bramley's Seedling also there were distinct differences in leaf colour, while the fruit from the unmanured plots had a much more mature appearance than that from those receiving the nitro-chalk.

The results of both trials are described in greater detail in a Progress Report in Section III.

The extreme measures adopted on the trees of Worcester Pearmain showed that, under the conditions of last Spring and Summer, a dressing of 15 cwt. was unquestionably too heavy, while a single dressing of 5 cwt. resulted in fruit of very good quality but was not sufficient to restore the foliage to a really healthy condition.

Except in 1932 both plantations have received a uniform annual dressing of 2 cwt. per acre of sulphate of potash from 1930 onwards.

(iii) *The Manuring of Young Trees from Planting.*

As in the previous year leaf scorch was severe on the plots which had received no potash. Where the comparatively small annual dressing of 2 cwt. per acre had been given since planting growth was very good and leaf scorch of little importance. The trees were two years old when planted on land that had been exhausted by crops of wheat and oats and after three years' treatment there are very distinct differences in tree size from plot to plot and from stock to stock.

The few apples harvested this year gave indications that a similar variation in fruit quality may be expected as soon as the trees come into cropping.

A preliminary trial of five different times of application of nitrogenous fertilizer has been started on some young Cox's Orange Pippin trees. No striking results have yet appeared. (W.A.B. and T.N.H.)

A further plot of two-year-old trees of Cox's Orange Pippin and Beauty of Bath on No. IX Jaune de Metz has been planted and will be used to study the effect of applying nitrogen at different times and in varying quantities. (J.A.)

PLUMS.

The pot culture experiment with the variety Victoria has been continued in collaboration with the Pathology Section. There has been a marked response on the part of the trees to certain of the treatments, and the results so far obtained are in accordance with those previously recorded with other fruits and with hops. So far it has not been possible to obtain any infection as the result of spraying the leaves with a suspension of the "die back" bacteria. This method of infection will be tried again during the coming season, and should it not prove successful stem inoculations will be given in the Autumn. (F.H.B. and H.W.)

(*i*) VARIETY COLLECTIONS AND TRIALS.

Observations made on the collection of apple varieties have been continued during the past year. They are being retained for at least one further year.

Those varieties which appear worthy of retention are being transferred to the cordon variety plot. As further varieties of possible interest become available they are being added.

Records are being continued on the cordon trees. (H.C.C. and A.B.B.)

(*j*) FRUIT BREEDING.

Rootstocks.

The programme of work in connection with the raising of new varieties of apple rootstocks combining immunity to attack by Woolly Aphis with the desirable characteristics associated with good rootstocks, being carried out jointly by the John Innes Horticultural Institution and East Malling, has been continued. During the past season approximately 1,000 seedlings were raised and passed over to the Entomological Section for artificial inoculation. Five hundred seedlings consisting of back and intercrosses between immune seedlings were raised at Merton and 500 seedlings consisting of crosses between Northern Spy and Paradise and Selected Crab rootstocks were raised at East Malling. Further pollinations were made during the past Spring when a series of crosses between Northern Spy, Winter Majetin, Transparent de Croncels, Reinette Zuccamaglia and Ben Davis were made at East Malling. It is expected that such crosses between two immune parents will give rise to a higher percentage of immune seedlings, in addition to which the possibility is being borne in mind that the seedlings from these crosses may in some cases prove to be new immune scion varieties of value, as well as rootstocks. Measurements of wood growth, girth of stem and counts of blossoms and fruit on one series of immune rootstocks, multiplied in quantity and worked with Lane's Prince Albert were made during the year. A satisfactory technique for the recording and cultural treatment of such nursery trials has been evolved. A further larger series will probably be worked during the coming season.

The crossing together of members of the Malling series of "Paradise" Apple Rootstocks with the object of evolving new rootstocks of economic value has been continued. During the past season seedlings were raised by crosses between Nos. I, II, IX and XII. Pollinations were made during the present Spring between Nos. VIII and IX. The series of apple rootstock crosses raised in 1929, now in their second year as stools, have given a further crop this year. They will be subjected to a careful examination later in the present season and selections for further trial will be made. A paper (E69) dealing with observations, extending over several years, on the inheritance of root and shoot characters in these seedlings was published during the past year. It was found that most of the characters studied were not of a sharply discontinuous nature, owing, it is thought, to the polyploid chromosome constitution of the apple. The observations were originally made in the hope that it would be possible to correlate certain easily distinguishable characters in the young seedlings with the later performance of the seedlings as rootstocks, thus making it possible to shorten considerably the period during which it is necessary to test them. Unfortunately the observations on the inheritance of characters in these seedlings make it seem extremely unlikely that this will ever be practicable. However, observations will be continued as time permits on those characters which have shown a more or less discontinuous inheritance. The whole of the members of two of the families in this series of crosses, multiplied in quantity, will be worked with Lane's Prince Albert during the coming season to provide information as to the manner in which the characters governing the influence of the rootstocks on the scion are inherited in the seedlings. Measurements of wood growth and girth of stem and counts of blossoms and fruits were again made on a series of selected seedlings of a cross between Nos. VIII and IX, raised at Merton in 1924, and worked in quantity with Lane's Prince Albert. Interesting differences in vigour and precocity are already appearing in these trees and careful observations are being continued. A further, larger, series of trees upon these rootstocks were worked during the past season.

A large number of crosses between varieties of plum rootstocks were made during the past year with the object of producing new varieties of plum rootstocks more easily propagated by the methods at present in common use and showing a wider range of influence over the scion variety. Of the twelve crosses made, five failed completely but this was probably chiefly attributable to the very severe weather conditions experienced immediately after pollination. Of all the crosses made the most compatible were those between Pershore and Brussels, and Common Plum and Brompton, while the diploid Myrobalan seedlings failed completely when inter-crossed. Taking all the crosses together of 2,442 flowers pollinated, 212 fruits, or 8·6 per cent. matured. It will thus be seen that progress in raising these plum rootstock seedlings must necessarily be slow. Further crosses will be made during the coming season.

A series of seedlings of *Prunus divaricata*, originally obtained from Asia Minor and the Caucasus through the John Innes Horticultural Institution and worked during the Autumn of 1932 with Czar plum to test their compatibility with this variety, have made a full year's growth. So far they show little evidence of incompatibility with Czar although some interesting differences in vigour are already manifesting themselves. They will be subjected to close observation during the next few years. A number of seedlings of apple, pear and quince, raised from seed received from Russia in 1929, will be stooled during the coming Winter to test their possibilities as rootstocks.

Scion Varieties and the Shortening of the "Juvenile Period".

During the past season several families of seedlings designed to produce new varieties of outstanding quality or extended season have been raised. A few further pollinations with the same object were made during the past Spring. The programme of crosses designed to shed light on the inheritance of fruit colour in the apple has been proceeded with. Observations have been continued on the series of seedling crosses worked on rootstocks Nos. IX, II and XII and planted out as cordons during the Winter of 1931, to test the influence of rootstocks in hastening the blossoming of seedling apples. So far these trees have not blossomed. Where the unit of trees of a single seedling upon one rootstock is sufficiently large the effect of differential methods of pruning is also being tried out. Material for a larger trial is in course of preparation. The grafts of apple seedlings worked on to a seventeen-year-old tree of Lane's Prince Albert during the Spring of 1932, to see how far this method would induce earlier fruiting in the seedlings, have continued to make vigorous growth throughout the season. Further grafts from a number of seedling apples were put on during the past Spring and have made good growth. About one hundred seedlings, now in their third year, being grown in pots to see how far the restriction of their roots will induce earlier fruiting, half of which have been kept under glass and half in the open air, have not so far shown any sign of blossoming. Already, however, the series under glass are showing a marked increase in vigour over those left in the open air.

A number of apple and pear seedlings, raised in 1930, and growing on their own roots, were planted out as cordons in their permanent fruiting quarters during the past Winter together with a batch of apple and pear seedlings raised from seed sent from Russia which are being fruited to see how far they will prove of use as new varieties.

A number of pear seedlings from crosses designed to produce new varieties of high quality were raised during the past year.

The experiments designed to discover the cause underlying the infertility of the Doyenne du Comice pear have been continued. Eleven trees of Doyenne du Comice on three types of quince, subjected to differential treatments, were pollinated with

Glou Morceau and Conference. Unfortunately, very severe weather conditions immediately following the application of pollen almost completely nullified the results of the pollinations during the past year. (H.M.T.)

(*k*) POMOLOGICAL ASPECTS OF SPRAYING.

Arising out of the Fungicide Trials (see Mycology and Bacteriology Section), the incidence of spray-damage continues to be observed in connection with factors such as rootstock, manuring, weather conditions and cropping. The data already obtained are very scanty, but it is hoped that they will be considerably supplemented in due course from the plot of young trees under different manurial treatments (see Pomology (*h*)). At present a general statement on the influence of these factors would not be justified. With regard to the repeated damage formerly caused on Cox's Orange Pippin by Bordeaux mixture at "full" strength (i.e., containing 8 lbs. copper sulphate per 100 gallons), it can now be stated that a reduction in strength to half was accompanied by obviation of spray damage. The weaker spray, however, was indifferently fungicidal. As with lime-sulphur, therefore, reduction in strength of Bordeaux mixture leads to greater safety on the tree, while the relationship between spray injury and fungicidal efficiency appears to be in direct proportion.

A field trial was started in 1933 to test the possibility of reducing lime-sulphur injury by the use of ferrous sulphate in the spray. (Success has attended work on similar lines by Hockey in Canada.) The varieties used were Cox's Orange Pippin and Worcester Pearmain, all trees being worked on No. II stock. Preliminary data have been obtained, but the trees are as yet too young to yield many results. Retention of the fungicidal properties of the spray will be looked for in future results.

(M.H.M.)

(*l*) MARKETING PROBLEMS.

The influence of such factors as variety, stock, pruning, thinning, cultural and manurial conditions, as heretofore, is being carefully watched in relation to market value over a period of years. (A.C.P.)

(*m*) KENT FRUIT SOILS SURVEY.

The joint survey of the Lower Greensand area in Kent has been prepared for publication in bulletin form.

The survey of the Hastings Beds area in Kent has been completed in conjunction with Wye College, and the joint report is in course of compilation. Two points of special interest in this survey are the close correlation that has been observed between tree performance and soil series and the many variations to be found in soil series within comparatively close topographical limits.

One soil series in particular was found to be associated with marked vegetative vigour in all fruits. Owing to the localized distribution of the soil series, however, it would clearly be impossible without further survey to forecast with any degree of accuracy how much of this desirable kind of soil there may be still available for planting in the parts of the Hastings Beds still unsurveyed. Of the top fruit surveyed roughly one-half consisted of trees of bearing age, the remainder being divided almost equally between trees under ten years and trees already past their prime. As between grass orchard and plantation management the top fruits were found to be grouped roughly in the ratio of 2 to 1, approximately 1,000 acres being in grass and 500 under some degree of cultivation. With regard to the distribution of mixtures of top fruit, about

60 per cent. was found to consist of apples interplanted with the plums and 10 per cent. contained admixtures of other kinds of fruit in addition to apples and plums.

(W.A.B. and N.B.B.)

(*n*) WALNUTS.

PROPAGATION.

Clonal rootstocks, for the purpose of grafting with good named varieties, are being raised by the layering method. In 1933 all the layers were treated with a mixture of "spent" hops and sand in the first two earthings, as freer rooting was found to result when this method was used in 1932. On opening up the stools, rooting of the layers was found to be better than in past years, satisfactory rooting being recorded for the first time on some selections of *J. nigra*. Slight rooting was also found for the first time on layers of named varieties of *J. regia*, indicating that there is reason to expect better rooting as the stools become older and the vigour of the annual shoots is reduced. Two hundred and thirty-five rooted layers have been cut off and planted in nursery rows preparatory to grafting with named *Regia* varieties. These layers consist of representatives of Royal and Paradox hybrids, *J. regia*, *J. nigra*, *J. sieboldiana*, *J. cinerea* and *J. mandschurica*.

In 1933, 320 grafted plants of twelve varieties that have been chosen as most suitable for growing in this country were raised under glass. These include a small trial in which pieces of root from established trees were used as stocks, thus showing the possibility of this method for the production of clonal rootstocks.

In the Summer of 1933 another budding programme was carried out in the open. In 1932, August was found to be the optimum time for budding, and in 1933 buds were put on chiefly in this month. In previous years the stocks have shown a good callus, therefore an attempt was made in 1933 to alter the physiology of the buds by ringing the shoots above or below the buds for use, at various intervals before budding. Other shoots were beheaded before the buds were used. It is hoped that some such method may result in a reliable budding technique.

Pruning experiments are being carried out with a view to the production of bush walnut trees for quick cropping in a restricted space. Trees that were lightly pruned in the Spring of 1932 developed short stubby shoots during the Summer; these in some cases are bearing buds which will grow out into catkins and fruit buds respectively in 1934.

One hundred and forty-two grafted walnuts were distributed to growers during the Spring of 1932. These include trees which were supplied to Denmark and to South Africa.

VARIETIES.

The dates of leafing out of trees in the Nursery and in the Variety Collection were again recorded. In addition, varieties injured by the late spring frosts of 1933 were recorded at the Research Station and on the six experimental sets of trees which were planted in different localities at the end of 1931. The importance of the late-leafing habit of the twelve varieties selected for rapid propagation was thus confirmed.

Records were taken on the growth and vigour of the experimental sets of trees, during the late Summer, and on the incidence of diseases. As these trees are now becoming established, interesting differences are becoming apparent between the same varieties in different localities.

A detailed classification of walnut varieties has been commenced, with a view to drawing up a table by which the better known varieties may be identified from their vegetative characters.

The nutlets on older trees at the Research Station were again hand-pollinated where catkins had not appeared, and notes were made of the dimensions, sealing, flavour, etc., of the resulting nuts.

Oil Content Determination.

The percentages of oil and moisture were determined in samples of fresh nuts from the trees selected at the Walnut Competition in 1929. It was generally found that the good quality is being maintained, and that a slightly higher oil content was reached than after the wet Summer of 1931.

Curing and Storage Trials.

An average sample from a local tree was used in these experiments. After removing the green, outer husks and washing the nuts, a portion of them was dried in the furnace room at 90° F. to constant weight.

The dried and fresh nuts were then bleached, a portion being left untreated in each case.

Several attempts were made to counteract the effect of moisture absorbed by impurities in common salt when used as a storage medium. This trouble was largely overcome by mixing the salt with sodium phosphate or with coco-nut fibre refuse, both of which counteract the deliquescent properties of the salt.

Samples of fresh and dried nuts were dipped in paraffin wax before storing. This method has now been abandoned owing to deterioration in flavour of nuts so treated, after a few months.

All nuts were stored under cellar conditions in the Winter of 1932. Hitherto suitable apparatus for drying the nuts successfully has not been available. In the coming season this problem of eliminating moisture from walnuts before they are stored will receive special attention. (J.B.H. and A.W.W.)

In Relation to the Small Fruits

(*a*) NOMENCLATURE, CLASSIFICATION AND VARIETY TRIALS.

A fresh planting of the four main groups of black currants has been made in order to maintain the continuity of crop records and meteorological conditions which have been kept since 1910. Various distances for planting different varieties are being tested, and this is also being tried out in a comparison with the New Seedling, Wellington's Triple X and Baldwin. (R.G.H. and J.A.)

The trial of clonal races of the principal varieties of classified red currants (in randomized blocks) yielded its first crop during the season. (J.A.)

The classification of the mixed material grown under the group name of "loganberry" has been continued. A number of visits has been made to commercial plantations, and has confirmed the opinion that the loganberry is not a clone and is also often mixed with the Phenomenal Berry. The botanical description and preliminary trial of the more important blackberry and dewberry varieties are being continued and several new varieties have been included. (A.B.B.)

(*b*) PROPAGATION AND ESTABLISHMENT OF CLONAL RACES.

The propagation of clonal raspberries has reached a further stage with the establishment of a Lloyd George nursery consisting entirely of clone material. Canes sent out in the Autumn of 1934 in small lots for the planting of cane nurseries will be taken from this plot. (See also Mycology, Raspberry Mosaic.) (R.V.H. and N.H.G.)

Satisfactory progress has been made in the establishment of a virus-free clonal race of Royal Sovereign, in collaboration with the Pathological Section.

Individual plant records of vigour, health and cropping have been taken on the 800 two-year-old clonal strawberry plants whose whole life history from the time of their formation has been recorded. This involved some 6,000 separate counts and as many weighings. Though in the first year the earliest formed runners had the most blossom, very little difference in cropping in the second year was found between plants of early and late origin, and between primary, secondary and lateral runners. The late formed runners, originally much smaller, had at the end of two seasons approximated in size to the larger earlier formed runners. (W.S.R., A.W.W. and J.L.E.)

The runners formed by twenty "2nd generation" clonal parents were lifted and weighed in the Spring, and 1,400 of them were divided into five different classes according to their time of origin and planted up as a uniformity trial. Individual plant records of vigour, blossoming, health, etc. are being taken. (J.L.E.)

A new runner bed was planted with the remaining material to test methods of raising virus-free material. About 3,000 runners were raised from a "3rd generation" of selected clone parents and from some two-year-old clonal parents. A trial was planted out in October, 1933 with runners from these one-year-old and two-year-old parents, and also runners from spaced and unspaced beds.

All plants planted in 1933 were hot water treated to eliminate insect pests, and every care is being taken to keep out disease by spraying and by removing diseased plants.

Several strains of Royal Sovereign have been collected for comparison, and clonal races of several other varieties have been started. (W.S.R. and A.W.W.)

Clonal stool beds of a number of blackberries, dewberries and loganberries have been planted. Experiments with regard to methods of propagation and transplanting are being continued and extended on clonal material as it becomes available.

(A.B.B.)

(*c*) PLANTING, TRAINING, PRUNING, ETC.

The first series of "strain", time of planting and de-blossoming experiments have reached their conclusion and the six years' records are now under review. The last year's crops were much reduced by the incidence of the "Yellow-edge" virus. The importance of this trouble is illustrated by crop records of a small number of comparable plants half of which were healthy both in 1932 and 1933 and half of which appeared healthy in 1932, but showed "Yellow-edge" in June, 1933. The crop was about one-third less on the "Yellow-edge" plants than on the healthy plants.

(W.S.R.)

The loganberry spraying and training trial is yielding useful information as to the comparative value of the four training methods, in limiting the spread of the spores of the cane-spot fungus from the old to the new cane. (See Mycology Section.)

(A.B.B.)

(*d*) MANURING.

The manurial trial of Lloyd George raspberries was concluded this year. The rapid deterioration of a large part of the field, due to mosaic and other diseases, led to

the grubbing of half the field in October, 1932 and the remainder was grubbed in September, 1933.

During these last two seasons since a report was published (Esf.21), the earlier conclusions were further established. The most interesting additional information has been with regard to Kainit. While in no year can it be said that Sulphate of Potash has harmed the crop, Kainit, when applied in March, has proved definitely detrimental to crop on two occasions—1929 and 1933, both of which were exceptionally dry seasons. In other more normal years the time factor has not been significant, or as in 1931, when a wet April followed a very dry March, the late application in March gave a better result than that given in December. It seems likely therefore that the use of Kainit on raspberries is inadvisable, since though it may do good in a wet year, in a dry year it may do definite harm, especially if applied as late as March.

Material is being raised for a further trial which it is hoped to plant in the Autumn of 1934. (T.N.H.)

(*e*) FRUIT BREEDING.

Black Currants.

An acre plantation of seedlings now in their sixth and seventh years, raised from crosses between the best selections from previous seedling families and the main varieties gave their second appreciable crop during the past Summer. Careful records were again made upon the fruiting characters and a number of further selections were made. In spite of the severe frosts during blossoming many of the bushes gave considerable crops. They are to be retained for a further season.

About 1,000 seedlings consisting of crosses between the main varieties, now three years old, fruited for the first time during the past season. The vegetative and fruiting characters of these seedlings were again recorded together with those of a number of self-pollinated families of the same varieties and an analysis of the records indicates that many of the characters of the black currant are apparently inherited in the manner usual to simple diploid plants.

A large number of seedlings have been raised from the seed of Baldwin and Boskoop Giant and of crosses between them, subjected to X-rays, and from seed produced from irradiated ovules and pollen. The treatments were applied during the Spring of 1932, at the John Innes Horticultural Institution. Germination was very variable and, so far, there is no evidence that the treatments have altered any of the morphological characters of the seedlings. Well over 1,000 seedlings will be planted out in their permanent quarters during the coming Winter and will be subjected to critical examination for several years to come.

Records of the crop on the large scale trial of Wellington's seedlings were again made and satisfactory crops were obtained. These three selections and particularly "Triple X" continue to be in demand among small fruit growers.

A number of hybrid seedlings from crosses between *Ribes longeracemosum* and various black currant varieties have been raised during the past season. A batch of three-year-old seedlings from crosses between the black currant and the gooseberry and the black currant and *Ribes longeracemosum* flowered for the first time last Spring. Unfortunately in no case did the flowers mature fruits.

Red Currants.

A number of families of the red currant seedlings, now seven years old, obtained by selfing the main varieties, gave their first considerable crop during the past season.

A number of the seedlings were of outstanding promise and will be closely watched during the next few seasons. No further families of red currant seedlings have been raised during the past season but records of botanical and fruiting characters are being continued upon the existing families.

A number of fresh *Ribes* species have been added to the Station's collection during the past season and careful descriptions of the botanical characters of the species are being continued.

STRAWBERRIES.

Observations were made during the past season on two families of seedlings from crosses between Royal Sovereign, Sir Joseph Paxton and Lefebre. They again showed striking differences in their susceptibility to "Yellow-edge" disease. Material has been prepared from certain of the seedlings and further crosses will be made during the coming season to determine how far susceptibility to the disease may be a question of genetic factors. (H.M.T.)

(*f*) FRUIT THINNING.

GOOSEBERRIES.

The experiments detailed in the last report have been continued. The results are being examined with a view to a progress report being made. (A.C.P.)

STATISTICS AND RECORDS

At the end of its sixth year, the Statistical Section finds itself very fully occupied in catering for the needs of other research workers, not only in other sections at this Station, but in increasing numbers from other Institutions.

If, therefore, the output of the Section, as shown by published reports, during the past year has been rather small, the reason is to be found in the larger number of reports from other sections, in the preparation of many of which the Statistical Section has played a not inconsiderable part. In addition, the experience gained at this Station in the layout and interpretation of horticultural experiments, has led to a big increase in the demands on the Section from other workers both at home and abroad.

Plot Layout.

During the past season, owing to the rapidly decreasing amount of ground available, the number of major experiments planned has been small.

Nevertheless, while the older trials continue to justify the great care which was taken in their preparation, a number of smaller trials, particularly in the nurseries, have been projected. A rather new departure has been the utilization of older experiments for new projects. The planning of some of these has been of necessity rather crude, since the original trials were not designed for this purpose ; and the fact that individual tree records of growth and cropping have been kept on the trees since they were planted alone makes such trials possible.

During the past year six trials have been planned for institutions overseas, and two at home. Apart from these several research workers have visited the Section in order to discuss their particular problems of plot arrangement and recording, while five have spent varying periods here studying modern methods of plot layout and analysis.

The experience gained by this outside work has been of great interest and mutual benefit.

Records.

A feature of the past season has been the large number of reports issued by the Pomology Section. This has entailed the preparation of summaries and tabled results of many of the major experiments, in particular the rootstock trials, over a period of some fifteen years.

The provision of a new Burroughs electric adding machine has helped materially with this work and the machine has been in constant use. Numerous requests for the loan of this and the other calculating machines in this office have made it evident that in the near future another calculating machine for general use will be required.

During the year a new uniformity trial of Strawberries using clonal material has been planted.

Records of size and cropping of individual plants are being taken and it is expected that this trial will form the basis for future strawberry experiments here.

Technique of Recording.

A considerable body of data with respect to the relationship between the various measures of vigour and cropping of apple trees have now been collected ; and it is hoped to produce a report in the near future. (T.N.H.)

PHYSIOLOGY

VEGETATIVE PROPAGATION (with Propagation Section).

(*a*) *Cuttings.*

The promising results obtained from increasing the moisture supply in the rooting medium and at the same time reducing water loss by shading are being followed up by an extended experiment. Further intensive trials are being made to analyse the influence of time and depth of planting, etiolation, planting medium and leaf fall on rooting of stem cuttings. With the help of the Statistical Section a trial of root cuttings of selected clone pear stocks has been planted. (R.J.G., R.C.K. and M.C.V.)

(*b*) *Layers.*

Detailed records have been taken at short intervals throughout the Summer of the growth of layer shoots of plums in the search for the factors producing wide differences of rooting of apparently similar shoots.

A census has been taken and will be repeated of individual layer shoots to determine the influence of size, thickness, position and etiolation on subsequent root production. (S.R.G.)

LEAF RELATIONS IN APPLES.

The Distribution of Leaf Surface.

A sampling method for determining leaf relations in large trees was worked out during the Summer and tested, in collaboration with the Pomological Section, on some sixteen-year-old trees of Bramley's Seedling on two stocks and under two manurial treatments. It was found that the method is sufficiently sensitive to show comparatively small differences between trees.

Another method for estimating the effect of experimental factors, such as rootstock and manurial treatment, upon the amount, time and character of shoot growth has been tested out on sixty-four four-year-old trees of Cox on the new Manurial Plot and has given satisfactory results.

Further investigations of both types have been planned for next Summer. (M.C.V.)

CARBOHYDRATE RELATIONS.

The technique which has been evolved for the determination of starch and some sugars in apple leaves is being applied to samples of spur leaves taken at intervals throughout the twenty-four hours from trees of Lane's Prince Albert on very dwarfing and on very vigorous stocks, in order to determine whether the diurnal cycle of changes of carbohydrate content is different in the two cases. (E.R.L.)

GROWTH.

Seasonal Course of Root and Shoot Development.

The data obtained in the investigation carried out on the unworked apple stock No. XIII are being analysed and prepared for publication. The results already obtained justify the extension of the investigation to worked trees. Maiden trees of two different

apple scion varieties, each on four different stocks, are accordingly being planted out this Winter and will be lifted in the form of six successive samples during the course of the growing seasons in 1934 and 1935. The trees in each sample will be submitted to a morphological analysis to determine the effect of scion variety and of rootstock upon the rates of growth of roots, stems and leaves at different times of the year. The detailed plan of planting and of sampling was drawn up in collaboration with the Statistical Section. (M.C.V.)

Effect of Scion on Root.

The trees of the apple varieties Beauty of Bath and Grenadier, that have been prepared for an investigation into the causes of the marked difference in amount of root growth in trees of these two scion varieties, were planted out last Winter according to a plan drawn up in collaboration with the Statistical Section. They will be ready for lifting and for morphological analysis next Summer. (M.C.V.)

Size of Tree in Relation to other Measurements.

The records of a large series of trees of Grenadier on VI have given full confirmation of the indication formerly obtained that " percentage fibre " in a root system decreases with increasing size of the system as a whole, other factors being equal. The proportion of stem was constant throughout a wide range of tree size and the ratio of weight of scion to cross sectional area of main stem increased with the weight of the tree.

(R.C.K. and T.N.H.)

Pruning (with Pomological Section).

The response of several series of trees, comprising many combinations of stock and scion, to different degrees of winter pruning has been determined by morphological analysis and a report is being published. New shoot growth and total new stem growth are progressively reduced by progressively more severe pruning, but a redistribution of stem growth is effected. Pruned trees, although showing less total stem increase than unpruned trees, dispose of a larger proportion of their stem growth in the formation of new shoots and a smaller proportion in the thickening of existing stems. The proportion of new stem growth to new root growth is unaltered by pruning. (R.C.K.)

BIOCHEMISTRY

Mutual Influence of Rootstock and Scion.

Ash Analysis.

A quantitative spectrographic method, applicable to the majority of the mineral elements occurring in fruit trees, has been found. This method, however, is not applicable to molybdenum, an element of peculiar interest (see previous reports and publications), titanium, vanadium, etc. ; but it is hoped that the difficulties presented by these elements are nearly overcome and that shortly a method now being devised will be applicable to all the mineral elements.

Functions of the Elementary Constituents (Tree Injection).

(*a*) *Distribution.*

Further work on tree injection has led to simple rules for producing at will the types of distribution required for experimental work and for commercial application, i.e. permeation of a whole tree (roots and top) ; permeation of single branches, and the roots in direct connection with them, each with a different substance ; permeation of twigs or branches each with a different substance without any of the substance getting into the roots.

These rules are based mainly on the vascular anatomy of the tree, but some consideration must be given to changes in the suction relations inside the tree resulting from the opening of the tissues to let in the injected solution.

Methods have been devised for avoiding certain pitfalls in the practical application of these rules.

This work will form the subject of two papers to be published shortly.

(*b*) *Avoidance of Damage.*

In collaboration with Mr. L. A. Thomas, of the Council for Scientific and Industrial Research, Australia, about 1,000 young apple trees were injected with the common artificial manures, both singly and in mixture. The main purpose of this work was to determine how far it is possible to avoid the damage which sometimes results from injecting even common artificial manures. The damage produced by all the artificial manures tried was similar to the type of leaf scorch associated with potash deficiency. The amount of damage may be reduced to nil either by reducing the total amount of substance injected or by increasing the volume of water in which it is dissolved.

Enough of any soluble artificial manure may be injected in two days in Summer to produce as great an increase in growth and vigour as that produced by the heaviest dressing ever applied to the soil ; and this can be done without causing any damage to the tree.

Enough manure to produce a marked increased growth may also be injected without damage in the Winter, but the maximum safe amount is less in Winter than in the Summer.

The toxicity of a given quantity of nitrate is less when in the form of a 4 : 1 mixture of potassium and calcium nitrates than if present as either of the pure salts ; and the

antagonistic ratios of these and other salts are approximately the same as those obtained by more usual methods.

The most convenient injection method is to drill one or sometimes two holes, a quarter inch or less in diameter, through the main stem or branch. Such a hole heals over in one season and there has been no evidence of such holes causing the tree any damage.

(*c*) *Results of Injection.*

The experiments were not designed primarily to demonstrate any beneficial effects of injection; but one such effect was established; a 25 per cent. increase in shoot extension growth resulted from injecting a mixture of potassium sulphate and ammonium phosphate.

Other results also point to the injection of single salts being beneficial; and the experiment as a whole has yielded data on the basis of which an experiment is being planned for next season to assess the beneficial results obtainable by injection of artificial manures.

The injection method may now be used with some degree of confidence for determining the functions of the various mineral elements absorbed by the tree from the soil; and it promises to be of use in a variety of physiological problems.

The method has been rendered sufficiently simple and inexpensive to make it applicable not only to large scale experiments but also as a commercial method. As a result of the increased control of the distribution of the injected substance a number of experimental and commercial applications of injection tried in the past with varying success can now be repeated and extended with a greatly increased hope of success.

The work reported in paragraphs (*b*) and (*c*) forms the subject of a joint paper to be published shortly.

Causes of Resistance to Woolly Aphis.

(See Entomology Section.)

Chemical Examination of Apple Bark.

Awaiting suitable assistance. (W.A.R.)

PLANT PATHOLOGY, MYCOLOGY AND BACTERIOLOGY

Crown Gall.

The experiments carried out to test the effect of applications of sodium nitrate to apple trees artificially inoculated with the crown gall organism (*Bacterium tumefaciens*) have been continued; the results will not be fully manifest until the end of another season's growth.

Galls on various host plants have been examined (i.e. loganberry, dahlia, mangold, vegetable marrow) and organisms have been isolated; these organisms are being compared with others previously isolated from crown galls with a view to studying their relation to crown gall on fruit trees and bush fruits. (H.W.)

Brown Rot Diseases.

Experiments have been continued for investigating the manner of leaf infection by *Sclerotinia cinerea* in relation to the wilting of plum stocks in the layered nursery rows. Infection resulting in the wilting of the shoots was induced not only by inoculating punctured leaves but also, in some cases, wilting appeared on shoots bearing leaves which had been inoculated without wounding.

Observations with special reference to recent severe outbreaks of Blossom Wilt have been recorded (C75, C90) and a further note on the infection of apples through the wound made on picking the fruit without stalks has been published (C93). (H.W.)

Bacterial Diseases of Fruit Trees.

Bacterial Canker of Plum Trees.

The morphological and physiological characters of the organism causing Plum Bacterial Canker have been studied in detail (C74). The organism shows certain cultural characters which distinguish it from *Pseudomonas prunicola* (previously described as causing a bacterial shoot wilt of plum trees) and the name *Ps. mors-prunorum* has been given to the Bacterial Canker organism. (H.W.)

The experiments to test the effect of soil conditions on the predisposition of trees to Bacterial Canker are being continued. (See Pomology (L) Plums.)

(R.J.G., F.H.B. and H.W.)

Bacteriosis of Cherry Trees.

The physiological tests are being extended to organisms isolated from lesions on leaves, branches and stems of cherry trees in order to determine what relation these organisms bear to the two species that are pathogenic to plum trees. (H.W.)

Spraying Trials.

Trials have been made testing Bordeaux mixture and zinc-lime on plum and cherry trees during Summer. No bacterial spotting appeared on any of the trees so the bactericidal properties of these sprays could not be determined. The Bordeaux mixture proved to be more injurious to the foliage than the zinc-lime. It seems possible that zinc-lime (a spray fluid recommended in America for use against bacterial spot of

peaches) may prove more useful, for bacterial leaf spot in plums and cherries, than Bordeaux mixture especially as its active ingredient, zinc sulphate, has proved, in laboratory tests, to be more toxic than copper sulphate to cultures of *Ps. mors-prunorum.*

(R.J.G. and H.W.)

RASPBERRY MOSAIC DISEASE.

1. *Analysis of Symptoms and Varietal Susceptibility.*

A description of Raspberry Mosaic as found in Britain has been published (C92). It is shown that there are three main symptom types, (*a*) mottling evenly distributed over the leaf with no distortion or curling of the lamina, (*b*) chlorotic patches ill-defined, accompanied by a symmetrical down-curling of the leaf: symptoms masked by high summer temperatures, (*c*) chlorotic patches sharply defined, not masked by summer temperatures. Varieties of raspberries differ in the rate of increase in the number of stools showing mosaic symptoms and in the relative rate of degeneration of infected stools.

An examination is being made of raspberry virus diseases in America, and grafting tests are being carried out in order to compare the various raspberry mosaic types in Britain with those in America with reference to their symptoms and virulence.*

(R.V.H.)

2. *Experiments in Commercial Control.*

The six cane nurseries for the production of mosaic-free canes of *Lloyd George*—one at the Research Station, and five elsewhere in Kent and Sussex—have again been twice rogued; they proved, as in previous years, to have a minute proportion of plants infected with mosaic. The demand for canes has been quite equal to the increased production, amounting this year to at least 60,000 canes in all. Almost the whole product of the parent nursery at East Malling has again been distributed for the planting of further cane nurseries; thus nuclei of mosaic-free material are now becoming fairly widespread.

The parent cane nursery, having become somewhat weak, has now been replaced by a fresh planting, consisting entirely of clone material.

In September two members of the Staff visited a number of raspberry farms in Scotland, chiefly in Angus and Perthshire. Whilst the mosaic position in Scottish *Lloyd George* plantations is not yet as serious as in England, there is ample evidence that the disease is spreading rapidly, and causing the usual degeneration of the plants, with a consequent shortening of the useful life of the plantations. A few plantations were found where mosaic infection in *Lloyd George* is still below 1 per cent. of the plants.

(G.H.B., N.H.G. and R.V.H.)

LOGANBERRY CANE SPOT.

This year the main spraying trial was planned with a view to determining the relative efficiency of Bordeaux mixture and lime-sulphur applied immediately before the flowers opened. Observations showed that Bordeaux mixture (6-9-100, made with hydrated lime) gave a better control than lime-sulphur.

Observations made during the Summer on the life-history of the fungus go to show that a fungicide incorporated with the second application of derris against loganberry beetle would be too late to check Cane Spot. This was actually found to be the case in a preliminary spraying trial.

* Mr. Harris is spending the period May, 1933, to May, 1934, in America (stationed at St. Catharines, Ontario) where he is continuing his observations and experiments on the virus diseases of Raspberry and Strawberry.

This Summer (1933) the fungus has been recorded on loganberry fruit.

Cane Spot records have again been taken on the trial plot of loganberries in which various methods of training are being tried out. (R.V.H and J.B.H.)

Strawberry Diseases.

The "Yellow-edge" Disease.

A full report of this disease has been published (C84). Grafting experiments are described which demonstrate the existence in this country of a virus disease of the strawberry. The principal symptoms (studied chiefly on the Royal Sovereign variety) are a general dwarfing of the youngest leaves accompanied by a yellowing of the marginal region and a curling and distortion of the leaflets. The petioles are short, stout and lacking in the normal red pigmentation. This disease, for which the name "Yellow-edge" is proposed, shows symptoms that bear a close resemblance to those of strawberry Xanthosis as known in America. Control measures are directed towards the elimination of virus-infected runners from the runner beds.

Observations are being made on the symptoms of the virus diseases of strawberries in America, particularly with reference to Xanthosis, for comparison with those of "Yellow-edge" of strawberries in Britain. (R.V.H.)

Root Rot of Strawberries.

The investigation of this disease was started last June. Although results to date are obviously exceedingly meagre nevertheless evidence has been obtained which points out that this trouble may be of considerable importance in connection with the general degeneration of strawberries. Several plantations have been found affected with this disease, which takes the form of a rotting of the roots of affected plants. A short note concerning this trouble was published in *Nature* (C70).

The above ground symptoms are a dwarfing of the leaves and petioles resulting in a flat type of growth, but with no yellowing or distortion of the foliage as in the case with mite, aphid or virus attack. Such above ground symptoms are, however, to be considered merely as an indicator of the disease, because definite diagnostic symptoms are to be found only on the roots. The root system of affected plants is very poor, many of the roots being dead, and many others showing definite black lesions on an otherwise healthy root. The lack of fibrous roots is pronounced. This state of the root system is brought about by parasitic soil fungi. So far a species of *Coniothyrium* isolated from diseased roots has consistently produced the disease on healthy clone plants growing in sterilized soil.

An extensive experiment has been set out in order that more critical work may be done on this disease next year. (G.H.B. and I.L.T.)

"Fruit-Russeting" and "Branch-Blister" Disease.

That part of this problem concerning growth of the associated fungus in pure culture, and subsequent inoculation experiments, has had to remain in abeyance during the past year, for the work requires much time that cannot at present be spared for it. Further examples of the occurrence of the disease in commercial practice have been observed during the year, and they served to confirm the opinion, stated in the last report, that the association of a fungus with the typical symptoms is likely to be secondary in importance to the influence of as yet undetermined environmental factors. The plot of young trees under different manurial treatments (see Pomology (*h*)) doubtless will, in time, afford a profitable medium for observations designed to find possible

correlations between the occurrence of disease symptoms and the manurial treatments. Meanwhile, information on the distribution and economic importance of the disease will be collected as it becomes available. (M.H.M.)

FUNGICIDE TRIALS.

Apple Scab and Apple Mildew.

When the last report was written, the second year's data obtained from a re-planned spraying and dusting trial had not been classified, but the conclusions there tentatively drawn are all substantiated by the classified figures now available. These have been written up for publication in the near future. Certain observations made in the same trial on the incidental control of Apple Fruit Sawfly, Red Spider and Brown Rot, by treatment designed for control of Apple Scab and Apple Mildew, were published separately (C86).

During 1933, it was decided to experiment extensively rather than intensively, using much of the information gained in intensive trials in an attempt to determine the best minimum spray-treatment for controlling Scab, Apple Fruit Sawfly and various Caterpillars in a Cox plantation. An account of the first year's progress will be found in Section III of this Report (Mycology and Bacteriology Section.) The pomological aspects of this work and of a distinct spray-injury trial are referred to under Pomology (Section (*k*)). (M.H.M.)

Pear Scab.

The results of two years' work (1931 and 1932) on the control of this disease have been published as a complete experiment (C85). A more popular account of the same trials appeared separately (C91). (M.H.M.)

" SPREADER " TRIAL.

A field trial of different " wetters " and " spreaders " has been in progress for the past two years in collaboration with Mr. H. Martin of Wye College. Four apple varieties, Allington Pippin, Newton Wonder, Worcester Pearmain and King Edward VII are included in the trial. All trees are worked on No. IX stock and there are about sixty trees of each variety. They are just coming into cropping. Certain as yet unclassified results have been obtained, but these are not sufficiently confirmed to allow definite conclusions to be drawn at present. (M.H.M.)

FACTORS AFFECTING SUSCEPTIBILITY TO APPLE SCAB AND MILDEW.

Further data on the effect of rootstock and manuring on susceptibility to Scab in Bramley's Seedling and Worcester Pearmain were obtained during the year. All the data so far collected will be classified and written up when opportunity offers. Root-stock-influence on susceptibility to Scab and Mildew in Cox's Orange Pippin is summarized in the unpublished reports referred to above. (M.H.M.)

APPLE CANKER.

Records on the infection by Canker of Cox's Orange Pippin and of Stirling Castle worked on different rootstocks have been collected for several years on the trees on the spraying trial plot (see " Fungicide Trials " above). These have been classified and will be found in a paper in Section III of this Report (Mycology and Bacteriology Section). (M.H.M.)

Diseases of Walnuts.

Walnut Bacterial Blight.

To control walnut blight, stem lesions were cut out of all trees in the Nursery and in the variety collection before the trees leafed out in Spring. The bacteria which cause blight have, however, been isolated from bud-scales during the Winter, as well as from stem lesions, therefore the diseases cannot entirely be overcome by cutting out the lesions. This being so, three applications of Bordeaux mixture were given to the nursery trees during the Spring and Summer, a few unsprayed trees being left as controls. Owing to wet weather shortly after the trees leafed out, blight spread early on the unsprayed trees, so that, in the Autumn, more infections were recorded on these trees than on those that had been sprayed. As a result of the hot dry Summer very few late infections occurred and three spray applications gave good control of this disease.

A Disease following Grafting.

Work has been continued on the fungus *Chalaropsis thielavioides* which has been found to infect nursery walnut trees. Its morphology and cultural characteristics are being compared with those of similar fungi isolated from carrots and from peach seedlings. These fungi are also being compared with *Thielaviopsis paradoxa*, a nearly related fungus.

Further experiments have been carried out to test the parasitism of *Chalaropsis* on other hosts, in order to determine the extent of its importance in this country.

Further investigations into methods of controlling the disease on walnut grafts have proved the efficiency of fumigation of the greenhouse by formalin, as an alternative to wet spraying. The possibilities of using Cheshunt Compound at a greater concentration than it is normally used, are also being tested. (J.B.H.)

Other Diseases.

Pear Bacterial Blossom Wilt.

Severe Blossom Wilt occurred on bush and cordon pear trees on the Station. The diseased tissues contained bacteria. Several strains of bacteria were isolated from the lesions, and they were tested for their pathogenicity; as flowers were not available by the time the organisms were isolated inoculations were made on young pear fruits. Four of the strains induced lesions on the fruit so these have been retained for further study.

Lilac Bacteriosis.

This disease which appeared in Wiltshire in 1932 occurred in two other localities in 1933. The organism causing this disease is being studied for comparison with the plum and cherry bacteria. It shows affinity with *Pseudomonas prunicola* and in preliminary inoculation experiments small lesions were produced on plum shoots with the lilac organism.

ENTOMOLOGY

The Control of the Fruit Tree Red Spider.

Experiments in relation to the control of the Fruit Tree Red Spider have not been continued this year, but further detailed records have been made upon the life-cycle of the mite under natural conditions. The winter egg laying period proved to be much earlier than usual, the oviposition period commencing in the middle of August and continuing until October. Many of the winter eggs were observed to hatch in September. Under normal circumstances the Fruit Tree Red Spider hibernates on the spurs of the trees in the form of a winter egg ; the eggs not hatching until the Spring. (A.M.M.)

Resistance of Rootstocks to Woolly Aphis Attack.

During the year, 961 seedlings have been tested for immunity. Of these, 504 were raised by Mr. M. B. Crane, of the John Innes Horticultural Institution, Merton, and were crosses of Northern Spy with immune seedlings Nos. 789 and 793. 245 proved to be immune, the percentage of immunity of the different families ranging from 44 per cent. to 55 per cent.

457 seedlings were raised at East Malling all N. Spy crosses, and 219 were found immune, the percentage of immunity ranging from 33 per cent. to 61 per cent. The most promising families were N. Spy × VIII 60·8 per cent. immune and Seedling No. 51 (Long Ashton OF5) × N. Spy 61·3 per cent. immune.

392 seedlings found immune last year were tested again and 293 remained immune. These have now been handed over to the Propagation Section to be tested as stocks.

The following young trees were also tested this year :

Alsop's Early two young trees both susceptible.
Kirk's two young trees doubtful.
Lady Carrington three young trees immune under our conditions.
Three two-year seedling trees from Seedling No. 799, all immune.

A number of check trees of N. Spy, Seedling 789 and Seedling 793 which were kept in the house and inoculated with the others remained immune throughout the season.

A number of immune seedlings tested at East Malling have been sent to India, Canada, South Africa, New Zealand, Australia, Argentine and Morocco to be tested for resistance to Woolly Aphis under their conditions. (A.M.M. and R.M.G.)

Causes of Immunity.

The investigations into the causes of immunity have been continued this year and progress has been made with the method of feeding the aphides on media prepared artificially from the bark of susceptible and immune varieties of apple. Media prepared by several methods from different chemical fractions of the bark have been compared in a series of trials and between some of these it has been found possible to obtain a difference in length of life of nymphs similar to that existing between the living trees. This suggests that the substance which confers susceptibility is extracted unchanged from the bark. Results have tended to confirm the previous inference that immunity

is due to chemical causes and that a solution of the problem may eventually be reached along these lines.

This investigation is being carried out in collaboration with the Biochemical Section. (W.A.R., A.M.M. and R.M.G.)

Woolly Aphis Parasite.

Weather conditions this year have been favourable for the spread of *Aphelinus mali* and in one orchard at East Malling where it was liberated in March, 1933, it has spread throughout the infected block of trees and parasitized aphids have been found at a distance of 144 yards from the point of release. The parasite, however, ceased to be active before the Woolly Aphis and winter colonies of aphis appeared on previously uninfected trees during October. This work is being carried out in collaboration with the Plant Pathology Laboratory, Harpenden. (A.M.M. and R.M.G.)

Apple Sawfly.

Extensive field spraying and dusting trials were carried out together with observations on the life history of the pest in order to determine which are the most vulnerable stages. The following were tested: Derris (in both wet and dry form), nicotine, lead arsenate, barium silicofluoride and a special combination of nicotine with a wetter and spreader.

A full account of the trials has been prepared for publication as a progress report, which throws new light on such points as the vulnerability of the egg and larval stages and the value of a Derris dust as a means of preventing oviposition.

(W.S. and G.L.H.)

Apple Blossom Weevil.

Tests of Derris dust as a means of preventing oviposition were made and have been described in a progress report. Some of the tests were of sufficient promise to justify further trials of Derris.

Experiments were continued to determine whether the weevils can be induced to shelter in chemically treated corrugated cardboard bands, which will in time destroy the weevils.

The destruction caused to the bands by birds and mice has also been noted, and some of the treatments tend to keep both birds and mice away.

(A.M.M., W.S. and G.L.H.)

The Apple Fruit Tortricids.

Detailed investigations have been made upon a number of Tortricids which infest fruit trees and also feed upon the maturing apples, etc.

Some 400 specimens of moths have been reared and great variety of species has been noted. Of these two or three species prove to be more abundant than the rest.

The life-cycles of the important species are being worked out, and a detailed report will be published concerning them.

The effect of certain gases upon the larvae of these moths, under gas store conditions, is also being studied. (A.M.M. and G.L.H.)

Systematic Study of Gall Mites.

A systematic study of Gall Mites which infest plants is being continued, and considerable trouble has been experienced in identifying species on account of the difficulty of preserving them in a satisfactory manner.

During the year one new species has been described (D84). (A.M.M.)

Tarsonemid Mites.

A collection of the species of mites of the genus Tarsonemus which infest cultivated plants is being made, and they will be studied as time allows. (A.M.M.)

The Strawberry Tarsonemid Mite.

The Strawberry Tarsonemid Mite has proved to be more serious than in previous years, and more details of its life-cycle have been observed (D87).

One aspect of the life-cycle is being studied in particular, namely, the mode of migration. Isolated plants, which were considered free of this mite, have become attacked, and it is thought that the mites may be carried by wind or insects from one plantation to another.

Experiments have been continued to determine whether young plants can be freed of this pest, before planting them out, by sterilizing them in warm water for a given period, at a known temperature. Results obtained this year clearly demonstrate that the plants will not only be freed of the Strawberry Tarsonemid Mite, but also from other important pests such as Eelworm, Red Spider and Aphis.

The recommendation suggested is that of sterilizing the plants in warm water at a constant temperature of 110° F., for a period of twenty minutes. After treatment the plants must be cooled off as soon as possible to avoid overheating. A suitable apparatus has been devised for the warm water treatment. (A.M.M.)

Strawberry "Yellow Edge" Disease.

Investigations are being continued in collaboration with the Mycological Section to determine whether the Tarsonemid Mite or the Strawberry Aphis is a vector of the virus described as "Yellow Edge" Disease. Direct inoculations have been made from mites and aphides from diseased and healthy plants, but so far negative results have been obtained. Virus symptoms have not appeared on a series of plants inoculated some two seasons ago.

These investigations are being continued. (A.M.M.)

Raspberry and Loganberry Beetle.

Further field trials on raspberries, loganberries and blackberries were carried out with Derris sprays of known rotenone content, and a progress report is being prepared.

The results confirm those of previous years (D85 and D86) and demonstrate the adequacy of a single application of a Derris spray on raspberries and loganberries and indicate that considerable latitude exists as regards the critical time for applying the spray. (W.S.)

Raspberry Shoot Moth.

An opportunity occurred of studying this pest (*Lampronia rubiella* Bjerk) in some detail. Observations were begun on its habits with a view to finding a suitable stage at which Derris sprays or dusts might usefully be applied.

Experiments on the control of the pest were begun but the preliminary results of these will not be evident before April or May, 1934. (W.S.)

Derris.

The main field tests of the use of Derris are referred to above in connection with Apple Blossom Weevil, Apple Sawfly, Raspberry Beetle and Raspberry Shoot Moth.

Valuable help in connection with the chemical evaluation of the Derris used was received from Dr. Tattersfield of the Rothamsted Department of Insecticides.

A start has been made with the biological work which forms part of a combined investigation with Dr. Tattersfield on the correlation of the toxicity of Derris with its various chemical and physical properties. (W.S.)

Phytocidal and Insecticidal Tests.

Experiments have been started to test the toxic effect of various potential sprays upon certain insect pests. Amongst these is included barium silicofluoride.

In addition the phytocidal effect of these sprays has been tested upon top and soft fruits. (A.M.M. and G.L.H.)

HOPS

Cultural Trials.

The trial of various distances between the hills and the number of bines per string on the seedling L21 has been continued. A Progress Report appears in Section III of this Report.

The effect of two distances of planting combined with two degrees of severity in pulling are being studied on the seedling OP21 (Oregon Cluster × English Male) × English Male.

A trial of three strains of Fuggles is being utilized for a cutting experiment. These two trials are now sufficiently established for the respective cultural treatments to be commenced.

Half an acre of the seedling OV7 (Late Bavarian × English Male) will be utilized for investigating the effect of varying severity in pulling and number of bines per string.

A seedling of promise in each of three grades of vigour (weak, medium and very vigorous) is being propagated for use in further cultural trials.

The more extended testing of the best of Professor Salmon's seedlings is being carried out in combination with the above cultural trials.

Distribution of Sets.

Sufficient rooted sets of the seedling OP21 to plant up half an acre at each centre are being supplied to two growers, one in the Kentish Weald and one in the West Midland area. This will enable us to judge the performance of this variety under two very different soil and climatic conditions. Cuts from these two centres will be available for the benefit of other growers. OP21 has been intensively propagated at East Malling and should provide several thousand sets for distribution next Autumn.

Smaller quantities of other varieties have also been distributed to growers in Kent and Sussex.

New Seedlings.

Seventeen varieties have been grubbed including three commercial varieties, badly affected with "Mosaic" disease. Twenty new seedlings have been planted in the place of those grubbed.

The crop from over 200 seedlings was dried separately, and bottle samples for resin analysis taken from eighty-three varieties. More than fifty varieties were pressed separately in part pockets to enable them to be used for brewing tests.

The analysis of the 1932 crop proved it to be considerably richer than that of 1931. In the early hops X35 was 1 per cent. higher in preservative value than the sample of Bramling analysed.

Amongst the mid-season hops, nine varieties proved richer than the best commercial variety (Mathon). In the late hops C9a is again top with a preservative value of 14·88 per cent. which is over 3 per cent. higher than the richest American hop (Sonomas). In three previous seasons C9a has beaten the richest American hops by smaller margins. This variety has cropped at an average of 25 cwt. per acre over five years, and is being planted up on a commercial scale by several growers.

No less than thirty-eight varieties proved richer than the Canterbury Golding, amongst which are several of the Manitoba and New Mexican classes, which are very heavy croppers and suitable for " Stouts ", with a P.V. equal to American hops.

Amongst the others OP21 and OV7 (see " Distribution of Sets ") have been used in brewing tests and found satisfactory, the former proving to be a suitable " dry hopper " in a recent trial.

This work is being carried out in collaboration with Prof. Salmon who has published a report (B22) and Mr. A H. Burgess, of the South-Eastern Agricultural College, Wye.

(F.H.B. and J.A.)

Section III

PRELIMINARY RESEARCH REPORTS

POMOLOGY

APPLE MANURIAL TRIALS

By T. N. HOBLYN AND W. A. BANE

Introduction.

When the first programmes of work were drawn up at East Malling, manurial experiments were not included to any great extent, attention being mainly concentrated on the standardization of material as a necessary preliminary to such experiments; the failure of previous workers to show consistent results from fertilizer trials being largely attributed to the fact that they were dealing with material of unknown potentialities.

When, however, the first large scale rootstock trial of Bramley's Seedling and Worcester Pearmain apples was planted in January, 1920, it was decided to include a sufficient surplus of trees on certain rootstocks for the purpose of making an elementary test of manuring as compared with no manuring. In this first experiment an attempt was made to compare the effect on trees growing on land which was in good heart at the time of planting, of a system of manuring based mainly on current practice, in which organic materials including dung, shoddy, meat and bone manures and sulphate of potash were used, with one where manures were entirely withheld, but non-leguminous green crops were ploughed in during some of the earlier years. In the early years, mainly organic manures, chiefly dung and shoddy, were applied to the manured plot, these being largely replaced by annual dressings of sulphate of potash as the results of other experiments became known.

By the Spring of 1923, the wide occurrence of leaf scorch, together with the preliminary results obtained by Wallace (8 and 9) in his pot experiments, led to the suspicion that potash deficiency was likely to be a serious problem on this soil and accordingly some $2\frac{3}{4}$ acres, on which were planted a large number of varieties under different pruning treatments, and known as the " Pruning Plot " were divided in half, one-half receiving dressings of sulphate of potash, the other half being left as a control.

The preliminary results of these two experiments have already been reported on (1 and 3). The important facts which emerged from these trials were (i) that in any experiment on the manuring of apple trees, not only variety but also rootstock would be likely to play an important part, and (ii) that on this soil, applications of potash were essential to the growth and cropping of the trees.

Since these trials were reported on in 1928 and 1930, a number of further trials have been projected. These include, firstly, a comprehensive trial based on the results obtained from these early experiments, which is designed to show the effect of the three main manurial constituents, nitrogen, potash and phosphate alone and in combination, on two varieties growing on a representative range of rootstocks. Secondly, the so-called " Starvation acre " has been utilized to investigate the parts played by nitrogen

and potash in the renovation of unmanured trees. Thirdly, a preliminary effort has been made to examine the problem of manuring apple trees growing under grass.

Since manurial experiments started at East Malling, the Station has been fortunate in having the valued co-operation of Dr. T. Wallace. Much of the work done here has been based upon his experience and during his frequent visits in connection with his fruit quality work his advice has been often sought and readily given.

For several years fruit from these experimental plots has been supplied to Dr. Wallace for storage and other tests of fruit quality, and his work in this connection forms an exceedingly valuable addition to the field work which has been done at this Station.

The following progress reports give a brief account of the pomological results so far obtained in the older trials.

Part I.

THE RENOVATION OF UNMANURED TREES.

As reported in 1930(1), at the end of the eleventh season the plot of Bramley's Seedling and Worcester Pearmain apple trees known as "Starvation Acre" had fallen behind its neighbouring plot, which had been subjected to a "balanced" manurial programme since planting, in vigour, cropping, health of the trees, and size and quality of the fruit. It was further reported that in this respect the variety Bramley's Seedling, which is a vigorous culinary variety, had suffered more than Worcester Pearmain, a highly-coloured dessert apple of moderate vigour, and that trees on the "semi-dwarfing" group of rootstocks, such as Nos. II, V, III, VII, etc. had been affected earlier and more markedly than those on the vigorous group, e.g. Nos. I and VI.

The experiment as originally started was continued until the end of 1930, by which time trees on the vigorous stocks (e.g. No. 1), which previously, though their fruit was small and of poor quality, had not fallen behind the manured trees in vigour to any extent, had shown signs of manurial deficiency in their growth.

During the Winter 1930-31 the attempt to renovate these trees by manuring was started. There were available for experiment some sixteen trees of each variety on eight different rootstocks, these being planted in 25 rows of 10 trees, the varieties being planted alternately and each rootstock occurring in two places on the plot for each variety. The necessity for guard trees to prevent robbing from one plot to another, however, seriously limited the number of trees which could be used for experimental purposes, and accordingly the plantation was divided into 12 plots, each consisting of a single row of 10 trees and separated from its neighbours by guard rows. In these 12 plots there were eight trees of each variety, on each of six rootstocks, Nos. I, II, IV, V, VI and X, and six each on Nos. III and VII.

This number of plots made possible the introduction of four treatments, which were limited to dressings of nitrogen and potash alone and in combination, and an unmanured control. This gave 30 trees under each manurial treatment consisting of two trees of each variety on each rootstock with the exception of Nos. III and VII, of which insufficient were available.

It may be considered that this unit of two trees on each stock under each treatment was dangerously small, and if the trees had been planted up especially for this trial, the unit would certainly have been larger. Nevertheless, the fact that there were,

under each treatment, thirty trees which had been separately recorded since planting, made the experiment worth while, provided the effect of the manures was more or less the same on trees on, at any rate, the majority of the rootstocks. It was realized, however, that this trial could not be expected to prove any but broad differences in the response of trees on different rootstocks.

Manures Applied.

The nitrogen was given in the form of sulphate of ammonia at the rate of 4 cwt. per acre every year in two dressings of 2 cwt. per acre each. The first dressing was applied towards the end of March and the second immediately after blossoming. This has usually been about the beginning of June.

The potash was supplied as sulphate of potash at the rate of 4 cwt. per acre in the Winter 1930-31 and at 8 cwt. per acre in the two succeeding seasons. This was applied during December.

The object of applying such heavy dressings of both nitrogen and potash was to try to accelerate the recovery of the trees, since Grubb had shown that trees receiving sulphate of potash at from $2\frac{1}{2}$ cwt. to 4 cwt. per acre had taken at least three years to recover (3).

The trees being planted at 15 ft. square, the manures were applied evenly over a 15 ft. wide strip ; that is to say, up to a line half-way between the manured row and the neighbouring guard row on each side. It should be made clear that these trees are being grown on land receiving the usual cultivations adopted for apples at the Research Station at the present time ; that is to say, cultivation is limited to disc harrowing in the late Winter and Spring. After the middle of June, no further cultivations are done until the following Winter. The usual routine sprayings are done on this trial as on other parts of the Station.

Records.

The records taken had two main objects in view :

(i) To record the effect of the manures on the growth and general health of the trees.

(ii) To show the effect on fruit production and fruit quality.

(i) The growth of a tree is shown in several different ways and it is insufficient to record but one of them. Thus it may take the form of shoot growth, stem and branch thickening or leaf area and texture. In order to get a true estimate of the effect of manuring, it is essential to obtain a picture of all these different forms of growth. Thus, it is possible for one manurial treatment apparently to produce an increase in stem cross section without a corresponding increase in shoot growth.

The recording of shoot growth on trees of this age is obviously a slow and difficult business, especially, as in the case of Bramley's Seedling, where the trees have not been leader tipped or spur pruned. However, such is the importance attributed to this aspect of growth that, in addition to the comparatively rapid observations of stem girth and height and spread of the tree, which were taken annually, shoot growth has been recorded on a small proportion of the Worcester Pearmains, which are leader tipped and spur pruned annually, i.e. eight trees each on rootstock Nos. I and II, and on sample branches on trees of Bramley's Seedling. Observational records on the size, colour and health of the leaves have been taken annually, these records including surveys of the incidence and intensity of leaf scorch and the dates of defoliation.

(ii) The actual crops produced have been recorded by counting the number of apples and the weight of fruit harvested. This is by no means the only way, however, in which the effect of the manuring has been shown, and such factors as amount and set

of blossom and size, colour and quality of fruit are of even greater importance, as all these factors contribute to the final value of the crop.

Records of amount of blossom and the subsequent set of fruit have been obtained annually on Bramley's Seedling on certain stocks and it was only limitations of time that prevented these most important records being taken on Worcester Pearmain as well. When the fruit was thinned counts of the thinned fruits were made and these records, together with counts of dropped apples and the final crop harvested, gave the total number of fruits produced by each tree. The crop was weighed in the field at harvesting. It was first graded for market under National Mark standards, which included six size grades and three grades for quality. As in this process of quality grading, the effects of colour and blemish were indistinguishable, further gradings were made for scab and red colour. In estimating colour, both surface area of the fruit coloured and the intensity of that colour were taken into consideration, for previous observation had led to the belief that a record of the former would not tell a complete story (2).

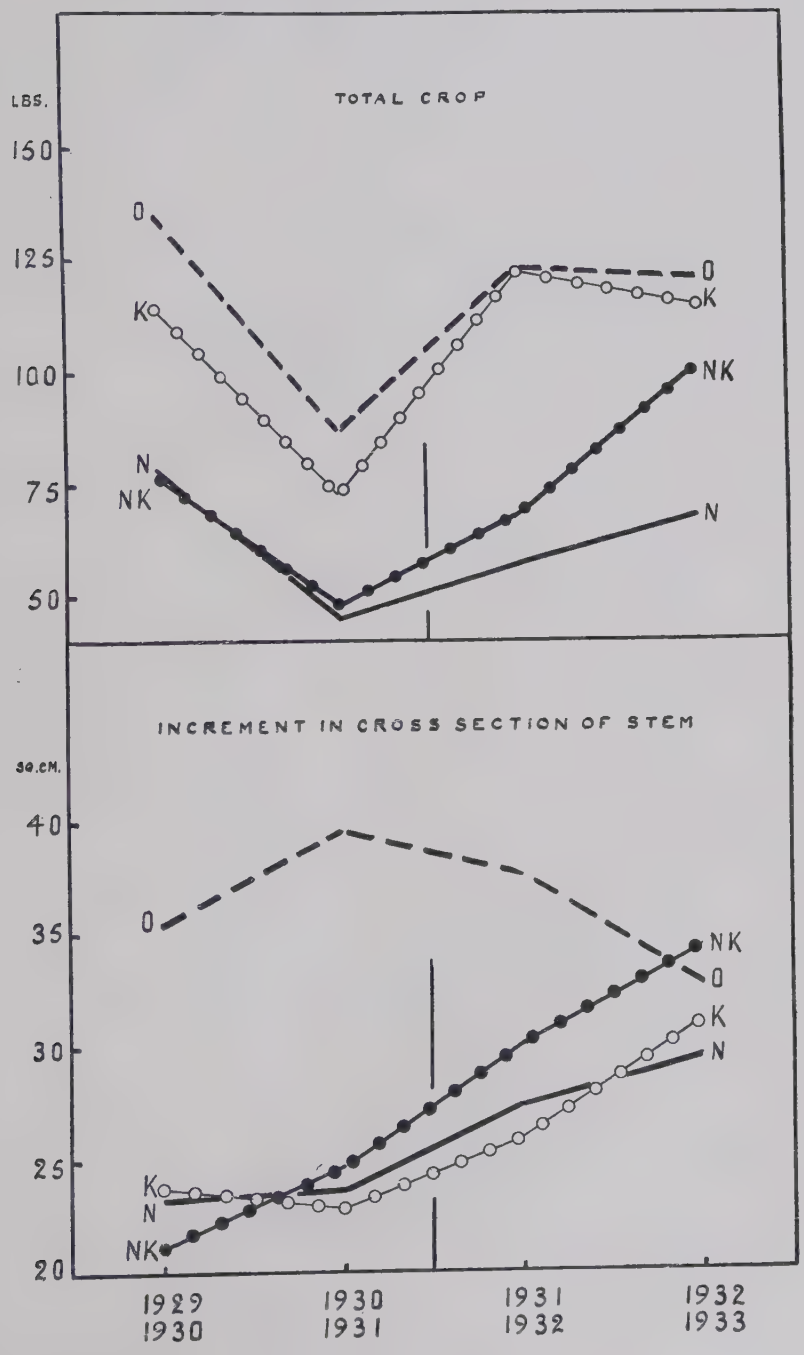
Three Years' Results.

In this progress report, the statistical methods used in analysing the data and testing the significance of the results, which are necessarily somewhat complex, will not be detailed. The results have, however, been subjected to such tests and only those of unquestioned statistical significance are to be here discussed. In estimating the effect of manuring on the growth or cropping of trees in an experiment of this kind, where the trees are in a low condition through a previous lack of manure, it is essential to know something of the history of the trees. Lack of manure must intensify the effect on the trees of local variations such as soil differences, and unmanured trees for this reason always tend to be more variable than those that are fully manured. In dividing up this experiment for the purposes of the new trial, owing to the position of the trees on different rootstocks and the small number of trees available, there was very little latitude in planning the trial to make allowance for variation already in existence. It frequently happened therefore that trees which were to have one treatment or another had a big advantage to begin with. This being the case, the only way in which the effect of the new treatments could be distinguished was by studying their performance after the application of the manures in comparison with that previously recorded.

As an example of this Figs. 1 and 2 show the cropping and increase in cross section of stem of Bramley's Seedling on No. II before and after manuring. This diagram shows these two characteristics in two year periods in order to eliminate the effect of biennial bearing—which is now very marked in this variety—and render the diagram clearer. It will be noted that the two trees which were due to receive no manure were very much larger and bore heavier crops in the two years previous to 1930, when the new trial was commenced, than those which afterwards received N, K and NK respectively ; and it is only by studying the subsequent history of those trees in relation to this fact that the effect of the manures can be seen ; since if the gross crops and increments in cross section alone had been considered, the " no manure " trees had actually given the greatest return.

The manures being applied during the Winter 1930-31, little response was to be seen during the succeeding season. It should be noted that in this season Bramley's Seedling, which had produced one large and two moderate crops in the preceding three seasons, had its first " off " year. In 1932 it was soon obvious in the foliage characters and amount of leaf scorch that manuring was beginning to have an effect. When the

GROWTH AND CROPPING IN TWO-YEAR PERIODS BEFORE AND AFTER MANURING BRAMLEY'S SEEDLING ON NO. II



FIGS. 1 and 2.

crops were harvested there were very big differences in fruit size in Bramley's Seedling, which bore very large crops in this season, and in colour of both varieties, and further definite differences in total crop harvested. At the end of this season, when the winter measurements were made, the differences observed in the Summer were shown in the increased growth and stem thickening. In 1933 these results were further intensified, especially in regard to vigour and size and colour of fruit—Bramley's Seedling was again in its off year—but though in this season there was little difference in the total weight of crop the characteristics of the fruits were very clearly marked.

General Effect of Manuring on Growth.

The clearest way to consider the results of this trial is to examine first the collective results from all rootstocks and then discuss how far the trees on each rootstock support the average of the whole. Table I shows the effect of the manuring, irrespective of rootstock, on the various aspects of growth of the two varieties in the trial.

These are considered separately owing to their totally different nature, but it is clear that in the main the results are very nearly the same for both.

In columns 1 and 6 of the table are shown the total increments in area of cross section of stem during the three seasons under review as compared with the increments in the two years 1929 and 1930. It should be noted here that increases in cross sectional area are given in preference to girth increments, since they give a real picture of the actual amount of stem thickening which the increments in girth do not. These figures show that both nitrogen and potash have resulted in a greater relative increase in cross section as compared with the no manure trees, but in both cases nitrogen has apparently had the bigger influence. This result was at first a little startling, as it appeared to the observer very obvious that those trees receiving potash had made very much more growth than where nitrogen only was applied. This is illustrated well by the photographs of trees of Bramley's Seedling under the four different treatments taken in the Autumn of 1932 (Figs. 3 to 6). This impression is supported by the figures analysing the number and average length of the shoots in columns 2 and 3, and 7 and 8. These show that though the differences in average length of a shoot were small, the number of shoots was very much larger on the trees receiving potash. The increments in height and spread are largely influenced by the space available, since the trees are only planted at 15 ft. square and this is now recognized to have been too close. Thus in parts of the plots where the larger trees are growing they have had to be pruned back in order to prevent them running into each other. Nevertheless, these increments do show on the whole the fact that trees under all three treatments have increased both in height and spread in comparison with the "no manure" trees. With Worcester Pearmain, the increments are small owing to the cutting back of the leaders each year. It may be noted that trees receiving both nitrogen and potash have in both cases increased the most.

With regard to foliage, it is not easy to express the differences in figures, but a brief description of the trees as they appeared to the observer in July, 1933 will show how the manures have affected this character.

(1) *No Manure.* Leaves thin and light green to yellow, spur leaves often deficient, about 50 per cent. leaves scorched.

(2) *Nitrogen only.* Leaves dark green rather thin, spur leaves often deficient—about 50 per cent. leaves scorched.

(3) *Potash only.* Leaves thick, medium green. Spur leaves good—about 30 per cent. leaves scorched.

Table I.

The General Effect of the Manuring on the Growth of Bramley's Seedling and Worcester Pearmain during the three years 1931-33 inclusive.

	Bramley's Seedling.					Worcester Pearmain.				
	Increase in Cross Section of Stem, 1931-33, compared with that in 1929-30.	New Wood Growth on sample of 5 metres wood during 1932.		Increase in Height.	Increase in Spread.	Increase in Cross Section of Stem, 1931-33, compared with that in 1929-30.	Actual Wood Growth per *tree* on Nos. I. and II. during 1932 and 1933.		Increase in Height.	Increase in Spread.
		No. of shoots.	Average length of a shoot (cms.).				No. of shoots.	Average length of a shoot (cms.).		
O	18·0	10	25·0	3″	3′ 5″	2·7	205	19·9	5″	1′ 11″
N	26·5	11	21·2	1′ 0″	3′ 3″	8·8	249	20·0	9″	2′ 4″
K	23·0	13	23·6	9″	3′ 11″	5·1	353	22·3	10″	2′ 7″
NK	39·1	16	24·4	1′ 5″	4′ 2″	11·6	424	22·5	1′ 0″	2′ 8″

(4) *Nitrogen and Potash.* Leaves thick, dark green, spur leaves good—about 20 per cent. leaves scorched.

Observations on leaf size have been made, but are greatly complicated by the "on" and "off" years of cropping—thus even "no manure" trees tend to have large leaves in the "off" year. In 1933, leaf scorch was considerably higher than in 1932 over the whole plot. This was undoubtedly connected with the drought, since leaf scorch is usually more severe in a dry year, and though the potash greatly reduced its severity, it was insufficient in such a season to prevent it altogether.

In both 1932 and 1933 surveys for leaf colour and amount of defoliation were made early in November. At this time the differences in leaf colour were very marked, the leaves for the most part being still green on the N and NK plots, while both the "nil" and "potash only" trees were very much more yellow for both varieties.

Table II shows the percentage of leaves fallen for the two varieties in the two years on the dates on which the plot was surveyed. It will be seen that in all cases nitrogen retarded defoliation very considerably and that in most cases the NK trees held their leaves rather longer than those that had nitrogen alone; though the significance of this is more doubtful. There is less difference between treatments for Worcester in 1932, but here again the NK trees held their leaves considerably longer.

TABLE II.

BRAMLEY'S SEEDLING AND WORCESTER PEARMAIN.

Mean Percentage of Defoliation early in November on all Rootstocks under different Manurial Treatments.

	Bramley's Seedling.		Worcester Pearmain.	
Date.	17/11/32	10/11/33	9/11/32	7/11/33
O	41	20	74	39
N	32	5	68	27
K	40	19	68	57
NK	27	2	52	27

The curious discrepancy between the effect of manures on stem thickening and the more obvious characteristic of woodgrowth was probably partly due to the cropping, since it is well known that the two factors, stem thickening and crop, are closely dependent on one another. As will shortly be shown, the trees receiving nitrogen only had considerably less fruit than any of the others and this probably to some extent accounts for their increased stem thickening. On the other hand, trees receiving both nitrogen and potash produced more fruit than any of the others, as well as a corresponding increase in growth in all its aspects. Cropping further influenced the increments in height and spread. For example, trees of Bramley's Seedling receiving potash only increased less in height and more in spread than those receiving nitrogen only. This is probably purely a mechanical effect connected with the larger crop of the former.

Here then is a definite case where even two measures of vigour have failed to show by themselves the actual state of the trees.

GENERAL EFFECT OF MANURING ON THE CROP.

Once again in examining the effect of the manuring on crop the previous cropping history must be taken into account, for though between trees on different rootstocks

Table III.

The General Effect of Manuring on Fruit Size and Colour and the Final Weight of Crop during the Years 1931-33.

	Bramley's Seedling.					Worcester Pearmain.					
	Total Weight of Crop, 1931-33 compared with that in 1929 and 1930.	1932 Crop.			1933 Crop.	Total Weight of Crop, 1931-33, compared with that in 1929 and 1930.	1932.		1933.		Average colour figure.*
		Actual No. of fruits per tree.	Average size figure.*	Average colour figure.*	Average ground colour figure. Trees on No. IV.		No. of fruits.	Average size figure.*	No. of fruits.	Average size figure.*	1932.	1933.
O	92·4	407	4·4	8·2	1·2	86·7	242	3·9	428	4·2	5·3	5·5
N	62·9	420	4·8	9·2	1·1	75·0	267	4·1	345	4·3	5·8	6·2
K	116·8	457	3·9	8·6	1·7	104·0	234	3·6	406	3·6	4·8	4·6
NK	137·3	499	3·9	9·8	1·4	109·3	265	3·7	340	3·7	6·0	6·5

* *Note.*—The limits between which the figures for average size and average colour vary are 1 to 6 and 1 to 12 respectively, the *lower* figure denoting the larger and more highly coloured fruits.

there is not necessarily a positive correlation between vigour and cropping, within a series on a single rootstock the largest trees are likely to have the biggest crops.

Table III shows the general effect of manuring, again averaging all rootstocks, on total weight of crop over the three year period, and size and colour of fruit during the last two seasons, when the manurial effect was becoming more obvious. As has been previously remarked, an important sidelight on the cropping of the trees is the amount and set of blossom. In each season four samples of five metres of wood, selected at random, were measured off on the trees of Bramley's Seedling on four different rootstocks and on these samples the number of blossoms was counted, capped or mildewed blossoms being afterwards omitted. These counts, while not attempting to estimate the total amount of blossom per tree, do give some idea of its concentration. These samples were carefully observed and counts made of the number of fruits immediately they had apparently set and again when the crop was harvested, though this latter count was found to be of little value owing to thinning, insect attacks and windfalls. Table IV shows the average number of blossoms per metre length of wood and the percentage of fruit set for Bramley's Seedling in 1932—the only year in which there was sufficient blossom to give reliable results. It will be seen that both the trees receiving nitrogen and potash had a greater number of blossoms than the "no manure" trees, but that nitrogen seems to have had the bigger effect. On the other hand, the small increase in "set" associated with potash is not significant and there is little evidence to show any effect of nitrogen in this respect.

TABLE IV.

NUMBER OF BLOSSOMS PER METRE LENGTH OF WOOD AND PERCENTAGE FRUIT SET ON BRAMLEY'S SEEDLING IN 1932.

	Nil.	N	K	NK
Number	49	69	61	70
Per cent. set ..	21·7	22·9	24·4	25·0

A point of considerable interest is the effect of manurial treatment on frost damage to the fruits of Bramley's Seedling. In 1933 severe frosts occurred when the blossom buds were still closed and as a result there was considerable russeting round the eyes of the fruit. Examination of the crop from trees on No. IV, the only rootstock available for this purpose, showed that while on the Nil and N plots the percentages of affected fruits were 39 and 36 respectively, in the presence of potash, i.e. on the K and NK plots, the figures were reduced to 21 and 19 per cent.

Records taken on the Meteorological Plot showed that severe frosts occurred from the 19th to the 23rd April, the Bramley's Seedling blossom first opening on the 24th and being full on the 28th. There were no frosts while the blossom was open.

In the absence of detailed records of time of blossoming on trees receiving the different treatments, it is not possible to say whether the variation in damage is due to this factor or to some difference in the texture of the skin of the fruitlet. Wallace (12) has found that in pot experiments omission of potassium usually advances the opening of blossom buds while deficiency of nitrogen delays it. He has also found that both potassium deficient fruits in store and vegetables are more liable to injury from low temperatures (10) (11).

The aggregate crop for the three seasons 1931-33 relative to the two seasons 1929 and 1930 is shown for the two varieties in columns 1 and 6 of Table III. It is very evident that potash both alone and with nitrogen has materially increased the total crop. Nitrogen alone, on the other hand, reduced the yield in both varieties though this reduction was considerably greater in Bramley's Seedling than in Worcester Pearmain. There is, however, some evidence to show that, in the presence of potash, it was beneficial, at any rate to Bramley's Seedling. The figures given for size of fruit partially explain these results. These "size figures" are calculated from the results obtained by grading the fruit over the Cutler Grader and are really simply the average grade for each group. These size grades run from 1 to 6, *grade 1 containing the largest fruits*, and represent quarter inch increases in diameter from 2 inches to 3 inches in Worcester Pearmain, and $2\frac{1}{2}$ inches to $3\frac{1}{2}$ inches in Bramley's Seedling. Thus for Bramley's Seedling there is an average difference of a whole grade between the trees receiving nitrogen alone and those receiving K and NK, the latter having the larger fruit. Differences in size in Worcester Pearmain were not so clear in 1932, but quite definite as between potash and no potash in 1933. It may well be asked whether these differences in size are connected in any way with the number of apples on the trees, but it should be remembered that in Bramley's Seedling the fruits were thinned to a single apple per truss every year, and the number of fruits in the individual years in the table show that, for Bramley's Seedling in 1932, there were actually more as well as larger fruits on the trees which received potash than on those which did not, whereas for Worcester Pearmain, the size seems quite independent of the number of fruits.

The significance of these "size figures" is further emphasized by Table V, which shows the proportion of apples which fell into each size grade for Bramley's Seedling in 1932. The preponderance of apples in grades 4, 5 and 6 for treatments O and N is very marked, while the big increase in grades 1, 2 and 3 for the K and NK trees amply demonstrates the difference in favour of potash. The fact that nitrogen only actually decreased the size of the fruits is shown by the large proportion in grade 6.

TABLE V.

BRAMLEY'S SEEDLING—ALL STOCKS.

Proportions in Size Grades.

	GRADES.					
	1	2	3	4	5	6
	Over $3\frac{1}{2}$".	$3\frac{1}{4}$–$3\frac{1}{2}$.	3–$3\frac{1}{4}$.	$2\frac{3}{4}$–3.	$2\frac{1}{2}$–$2\frac{3}{4}$.	Under $2\frac{1}{2}$.
O	1·5	4·7	17·4	35·1	17·7	23·5
N	1·0	2·2	9·9	28·1	23·3	35·5
K	3·7	10·2	26·6	28·7	14·3	16·5
NK	3·8	9·4	24·0	30·1	15·1	17·7

Returning to Table III the effect of the treatments on the red colour of fruit is shown in columns 4, 11 and 12—in 1932 for Bramley's and in 1932 and 1933 for Worcester Pearmain. As has been previously noted, the fruit was graded into four grades for amount of red colouring by the method described by Rogers (5) and into three for intensity; these were recorded as 1, 2, 3 and 4 and 1, 2 and 3 respectively.

grade 1 being the highest amount and most intense colour in each case. In order that the standard should be the same from year to year, the grade colours were fixed as closely as possible by the use of Ridgeway's Colour Standards (7). In estimating the " colour figure " the amount grade was multiplied by the intensity grade, so that apples for example which were more than three quarters coloured, and thus fell in grade 1 for amount, and whose intensity was also grade 1, would be given a value of 1, whereas apples which fell into amount grade 4 and had the lowest intensity, i.e. 3, would have a colour figure of 12. The averages in the table are the mean colour figures for each treatment.

The most striking point which emerged from these colour gradings was the great reduction in colour where nitrogen was given, even where potash was applied as well. This is evident in both varieties, and while it is an obvious disadvantage in Worcester Pearmain, in Bramley's Seedling the greener apples are possibly the more desirable. Potash by itself definitely increased the colour of Worcester Pearmain in both years, and this is evident both in amount and intensity. The fact that the NK trees always had even less colour than the " nitrogen only " trees is probably partially an indirect effect of the manuring due to the much greater density of the foliage ; since for Worcester Pearmain the low colour figure under this treatment was, in the majority of cases, due to a lesser surface area coloured, rather than a reduction in intensity of colour. It should be further remarked that though little difference appears in the colour figures for Bramley's Seedling between the N and NK trees, the quality of the greenness was very different. Apples from the trees receiving nitrogen only were of a whitish, unhealthy looking green, whereas those receiving nitrogen and potash were of a bold healthy green differing completely from the former. In 1933 an attempt was made to grade the Bramley's Seedling apples for ground colour. These were divided into three grades, using the method described by Palmer (4). In this case, grade 1 was definitely green, whereas grade 3 was yellow, grade 2 being intermediate. The figures in column 5 give the average ground colour grades for each treatment and show that whereas the trees receiving nitrogen only gave the greenest fruit, that from trees getting potash alone was very much more yellow. This does not necessarily mean that the " potash only " apples were the ripest, for they were definitely harder at this time than the very green " nitrogen only " apples, a fact which was especially noticeable owing to the much greater amount of bruising which these latter apples showed, after the normal operations of picking and grading. These ground colour figures were obtained from the apples on No. IV only, this being the only stock on which large enough crops were available, but the few apples harvested from the trees on the other stocks amply confirmed this result and in some cases the differences were considerably more definite.

To sum up, the two manurial constituents applied evidently influenced different characteristics in the trees, some positively and others negatively, but neither alone was sufficient to produce normal vigorous growth and heavy crops.

Potash evidently increased shoot growth, amount of crop, and size and quality of fruit. Nitrogen increased the amount of stem thickening and the green colouring of the leaves—it, however, had a detrimental effect on crop, particularly on the size and colour of the fruit.

This detrimental effect on crop is possibly connected with the increase in stem thickening of the " nitrogen only " as compared with the " potash only " trees, but the fact that, not only in this trial but also in the trials to be discussed in Part II of this paper, nitrogen has always produced more stem thickening, leads to the belief that there is a definite effect of nitrogen on this growth character.

Differential Response of Rootstocks to Manuring.

Up to the present the general results, averaging all rootstocks, have been considered. It now remains to be seen how far the trees on each of the rootstocks in the trial conform to the average. As has been pointed out, the unit on each rootstock is very small—only two trees—so that unless indications of a differential response are very

Table VI.

Bramley's Seedling. Relative Increase in Cross Section of Stem and Total Crop 1931-33 as Compared with the Two Seasons 1929-30.

	Cross Section.					Total Crop.				
Manurial Treatment.	O	N	K	NK	Mean.	O	N	K	NK	Mean.
Rootstock No.										
I	15·2	10·8	30·1	46·2	25·6	151	12	85	121	92
II	30·1	31·0	35·8	52·6	37·4	45	19	82	102	62
IV	9·1	13·2	4·8	15·4	10·6	199	163	261	97	180
V	7·6	36·7	32·7	45·8	30·7	−14	29	43	100	40
VI	24·9	51·5	27·4	46·0	37·5	117	115	146	324	176
X	21·3	15·7	7·2	28·6	18·2	56	39	83	79	64
Mean	18·0	26·5	23·0	39·1	26·7	92	63	117	137	102

definite they should not be regarded too seriously. Nevertheless while, as will be seen, in the majority of cases the results are consistent or do not differ to a significant extent, there are certain outstanding exceptions which are worth commenting on.

Bramley's Seedling.

This variety as a whole has shown more definitely the responses to manuring, differences being obvious in 1932, which did not appear in Worcester Pearmain until the following year. The relative increments in cross section of stem and total crop compared with 1929-30 for the three years are given in detail for each rootstock in Table VI.

In stem thickening, though Nos. I and II do not seem to agree with the majority the differences are not sufficiently marked to be seriously considered. The crop results as shown by the average were true in the main for all stocks, though the detrimental effect of nitrogen alone on crop was not obvious in No. VI. Trees on No. V before 1930 had cropped poorly compared with those on other stocks. In the years after manuring, although nitrogen apparently benefited trees on this rootstock, the difference in cropping between these trees as a whole and those on other rootstocks was actually accentuated; the poor cropping of trees on this stock is evidently connected with the fact that the set of fruit was significantly lower, and the actual fruit smaller than on other rootstocks. The well-known susceptibility of trees on this stock to leaf scorch was once again demonstrated in this experiment. Trees on No. VI increased markedly in vigour and cropping under all treatments, though still showing manurial effects. It will be remembered that No. VI was one of the stocks to suffer least from starvation earlier. Trees on No. IV cropped much more uniformly from year to year than the rest and, in consequence of this heavy cropping, showed a marked falling off in growth. Though with regard to biennial bearing, most

of the trees on this stock have been apparently out of step with those on other stocks—the greater set of fruit, especially where the trees had potash only, in the " off " year 1932, which was the " on " year for the majority, partially accounts for the uniform cropping. This also, partly explains the fact that this stock differed from the majority in that potash had little effect in increasing fruit size in 1932, for, while those receiving no potash had comparatively low crops, those with potash cropped as heavily as many of the trees on other stocks in their " on " year.

Although there were no outstanding deviations from the main manurial story with regard to leaf colour and time of defoliation, No. IV may be noted as turning colour and defoliating earlier than the rest, while Nos. VI and X seemed to keep their green colour and hold their leaves longer.

Worcester Pearmain.

Table VII shows the individual relative increments, in cross section of stem and crops for Worcester Pearmain. Although the general effect of the manures on growth and cropping was apparently much the same, though not so well defined as for Bramley's Seedling, the effects on Worcester Pearmain on individual rootstocks were not nearly so consistent, indeed on no single rootstock were they completely in agreement with the average of the whole. As was pointed out in the earlier report, Worcester Pearmain felt the effects of the lack of manuring more slowly than Bramley's Seedling, and even with the simple issue then under trial, the results were difficult to disentangle. However, though quantitative results are difficult to explain, for the most part qualitative characters such as size and colour of fruit are more consistent ; and it may be confidently expected that in time the quantitative results will become better defined.

TABLE VII.

WORCESTER PEARMAIN—RELATIVE INCREASE IN CROSS SECTION OF STEM AND TOTAL CROP 1931-33 AS COMPARED WITH THE TWO SEASONS 1929-30.

	CROSS SECTION.					TOTAL CROP.				
Manurial Treatment.	O	N	K	NK	Mean.	O	N	K	NK	Mean.
Rootstock No.										
I	—0·3	7·2	9·8	12·2	7·2	33	79	109	176	99
II	2·8	11·2	9·1	18·4	10·4	62	86	100	124	93
IV	—1·5	—9·7	—1·1	4·6	1·9	104	99	96	117	104
V	—4·3	16·5	—6·9	13·2	4·6	129	40	113	51	83
VI	10·0	21·3	5·6	16·3	13·3	144	63	129	124	115
X	9·6	6·5	13·9	5·0	8·7	47	84	76	64	68
Mean	2·7	8·8	5·1	11·6	7·1	87	75	104	109	94

The principal deviations from the general effects on total crop and increase in cross section were as follows. Trees on Nos. I and II benefited considerably from both nitrogen and potash ; the detrimental effect of nitrogen alone on total crop was not obvious and indeed on No. I nitrogen appears to have increased the size of the fruit.

Trees on No. IV again cropped consistently heavily every year, and though nitrogen and potash together apparently had their effect in increasing growth, except for the influence of potash in increasing fruit size, there was little other evidence of manurial

effect. The high colour of the fruit was very striking under all treatments. No. V showed no sign of benefit in total crop from manuring, indeed nitrogen, either alone or with potash, materially reduced the crop. This decrease in crop was probably connected with size of fruit, for the fruit from these trees appears to have suffered most in size from nitrogen, though it showed the good effect of potash.

The gross effects on growth and cropping of trees on Nos. VI and X are still somewhat nebulous, but the influences of potash and nitrogen on size and colour of fruit in general conformed to the average.

Once again the leaves on No. IV were the earliest to change colour, while No. X was again outstanding in being the latest to turn colour and defoliate.

It is evident, therefore, on the whole, that though the results on Worcester Pearmain do seem to conform with those from Bramley's Seedling, this variety is taking longer to show definite results. Further, it seems probable that differential responses of rootstock to manuring may be more defined with this variety.

Discussion.

In conclusion, it may be emphasized that, though this experiment is still in progress and another season is needed before the results can be complete, the heavy dressings of sulphate of potash applied did under our conditions effect a remarkable recovery in the trees in two seasons, especially in the case of Bramley's Seedling. By itself, nitrogen on the whole had a detrimental effect, but that it also was needed is well shown by the vigorous condition and generally increased returns where both sulphate of ammonia and sulphate of potash were applied.

Differences in size and colour of fruit were very striking in the second and third seasons. For Bramley's Seedling, the apples from the " nitrogen plus potash " plots were evidently the most desirable. Nitrogen, however, reduced materially the colour of the fruit of Worcester Pearmain, the " potash only " plots producing the most highly coloured fruit, though whether this was also the best quality fruit is open to question.

Though these results are generally true, the response of different rootstocks has not always been the same, this being particularly the case with Worcester Pearmain. No. IV maintains its reputation for heavy cropping and seems to have shown manurial differences less clearly than the remainder. No. V has once again produced very poor crops, a fact now for the first time associated with a poor set of blossom, as well as small fruit, and has shown manurial differences very clearly.

Part II.

THE TREATMENT OF TREES UNDER GRASS.

It may be recalled that when the original rootstock trials of Bramley's Seedling and Worcester Pearmain were planted, the distance of planting was 15 feet square. At that time the plant was criticized as allowing too much ground for trees growing on " paradise " rootstocks. Nevertheless by the time they were eleven years old, the trees on the two fully manured plots were already becoming overcrowded, at least where they were worked on certain " paradise " rootstocks, which had now proved to be in every respect as vigorous as the so-called " crab ". In addition, owing to the exuberant

growth, the Worcester Pearmains were producing poorly coloured fruit of low market value. The problem, therefore, arose as to how these plots were to be treated, for either the growth of the trees had to be checked in some way, or one or other of the varieties, which it will be remembered were planted alternately, had to be removed. This latter operation would have been highly undesirable owing to the question of pollination.

It was thus determined to try in the first place the less drastic course of checking the growth of the trees ; and with this in view, one of the two 1¼ acre plots (Plot 12), which had previously been subjected to manuring as already described (1), was laid down to grass in the Spring of 1930, the grass being chiefly perennial rye grass with a small proportion of cocksfoot. The grass was to be treated under the sod mulch system ; and with the object of comparing this method with ordinary cultivations the neighbouring Plot 13, which up till that time had received similar treatment to Plot 12, was cultivated as before. Both plots had a light dressing of sulphate of ammonia in July, 1930. From that time until differential nitrogenous manuring was started in 1933, no nitrogenous manures were applied to either plot, but in 1930 and 1931 both received a dressing of sulphate of potash.

Under the sod mulch system of cultivation the grass was cut at least twice during the season and the mowings raked up round the base of the trees and allowed to rot. The first cut was made when the grass was about 1 foot high, usually towards the end of April, and the second cut generally a month later, according to the state of the grass.

Problems of cutting the grass under these conditions have arisen, but these need not be entered into here. They did not become acute until later, when nitrogenous manures were applied, since the growth of the grass until then was very sparse. The range of rootstocks included on these plots was considerably wider than that on the so-called "Starvation Acre", and in addition to the " vigorous " and " semi-dwarfing " stocks on that plot, there were included representatives of the " very dwarfing " group, such as No. IX, and of the " very vigorous " group, such as Nos. XII, XIII, XV and XVI.

The records of growth and cropping which were made on these trees to examine the effects of grass have been more or less the same as already described for the " Starvation Acre " ; there is thus no need to recapitulate here.

History of the Experiments during the Period under Review.

During the first season after sowing, the growth of the grass was not very strong ; however, by the end of the season its effects on leaf colour and earliness of defoliation were quite evident, especially on trees worked on the more dwarfing rootstocks.

In 1931 detailed records on leaf colour and fruit size and quality, as well as the routine records of growth and crop, were begun ; and in this year the effects of grass on all these characteristics were very marked, the yellowing of the leaves and the very highly coloured fruit being especially noticeable.

In 1932 the grass plot showed very clearly the symptoms of nitrogen deficiency. The previously mentioned characteristics were even further defined and in addition spur leaves were very small, spurs often dying out altogether. Further the size of the fruit had decreased, much of it being hard and woody in texture, and though of wonderful colour, of very poor flavour. The effect of this treatment without any additional nitrogenous manuring was thus seen to be extremely deleterious in the third season, and it was evident that if the trees were to be brought back to a productive and healthy condition, either the grass must be ploughed up or the trees assisted by heavy nitrogenous dressings.

It follows that this method of checking growth was by itself bound in the end to cripple the trees, but if they were restored to their former vigour the overcrowding factor would once again become critical. It was therefore decided in 1932 to sacrifice the Bramley's Seedling trees and concentrate on trying to keep the balance between healthy growth and profitable, well coloured crops on the Worcester Pearmains by manuring through the grass.

In the meantime the neighbouring plot (No. 13) which had remained under cultivation, had become so overcrowded that, even by removing the Worcester Pearmains altogether, the Bramley's Seedling would soon be likely to be too close. In the Spring of 1932, therefore, this plot also was grassed down and the Worcester Pearmains removed the following Winter. But in this case an effort was made to maintain the trees in a vigorous state by applying nitrogen from the start.

THE EFFECT OF GRASSING DOWN.

Growth and Cropping.

The effect of the grass during the limited period of the experiment was probably of much greater importance on leaf characters, fruit-bud formation and size and quality of fruit than on actual total growth and cropping. Nevertheless that there was a steady falling off in growth on the grass plot as compared with its neighbour is shown in Fig. 7. This diagram shows the average annual increments in cross section of stem and the annual crops for the two varieties on all rootstocks under grass and cultivation. Whereas the annual stem thickening of Bramley's Seedling fluctuates from year to year, and that for Worcester Pearmain gradually increases under cultivation, on the grass plot there is a steady falling off for both varieties. As has been previously stated, this characteristic of vigour is largely influenced by fluctuations in crop, and indeed the Bramley's Seedling under cultivation show a marked negative correlation between the crop and stem thickening over this period as illustrated in the diagram, there being low increments in cross section of stem in the years of heavy crop, and vice versa ; but the effect of grass in causing nitrogen deficiency is evidently so great as to outweigh this correlation, since the falling off in growth is quite independent of crop fluctuations on this plot.

The influence on total crop is a little more obscure. In the first season there was evidently no effect. In 1931, however, the grass apparently had a beneficial effect on the cropping of both varieties, for Worcester Pearmain, which had comparatively good crops on both plots, averaged some 16 lbs. per tree more under grass. Bramley's Seedling, having cropped steadily since 1928, when the trees first came into cropping, had its first definite "off" year in 1931. But this variety did not show this first sign of biennial bearing nearly so markedly on the grass plot as on the other, and this in spite of the former plot having previously cropped rather more heavily. In actual fact trees on certain stocks (e.g. Nos. I and II) on the grass plot cropped as heavily in 1931 as in 1930, and up to date have never had an "off" year, while on others, notably Nos. V and XVI, the biennial effect was as marked as on the cultivated plot. Though there is some evidence to show that Nos. V and XVI had a biennial tendency earlier than the rest, there is no apparent reason why certain stocks should crop exceptionally well in 1931, while the majority on this plot did not.

In 1932, however, the grassed plot had considerably less crop than its neighbour, and how much of this is due to the effect of previous high crops and how much to the deleterious effect of the grass on fruit bud formation it is difficult to say.

It seems possible that the effect of grass in the first year, in checking the growth, was to encourage fruit bud formation, at any rate on certain rootstocks ; but after that,

THE EFFECT OF GRASSING DOWN ON GROWTH AND CROPPING OF BRAMLEY'S SEEDLING AND WORCESTER PEARMAIN

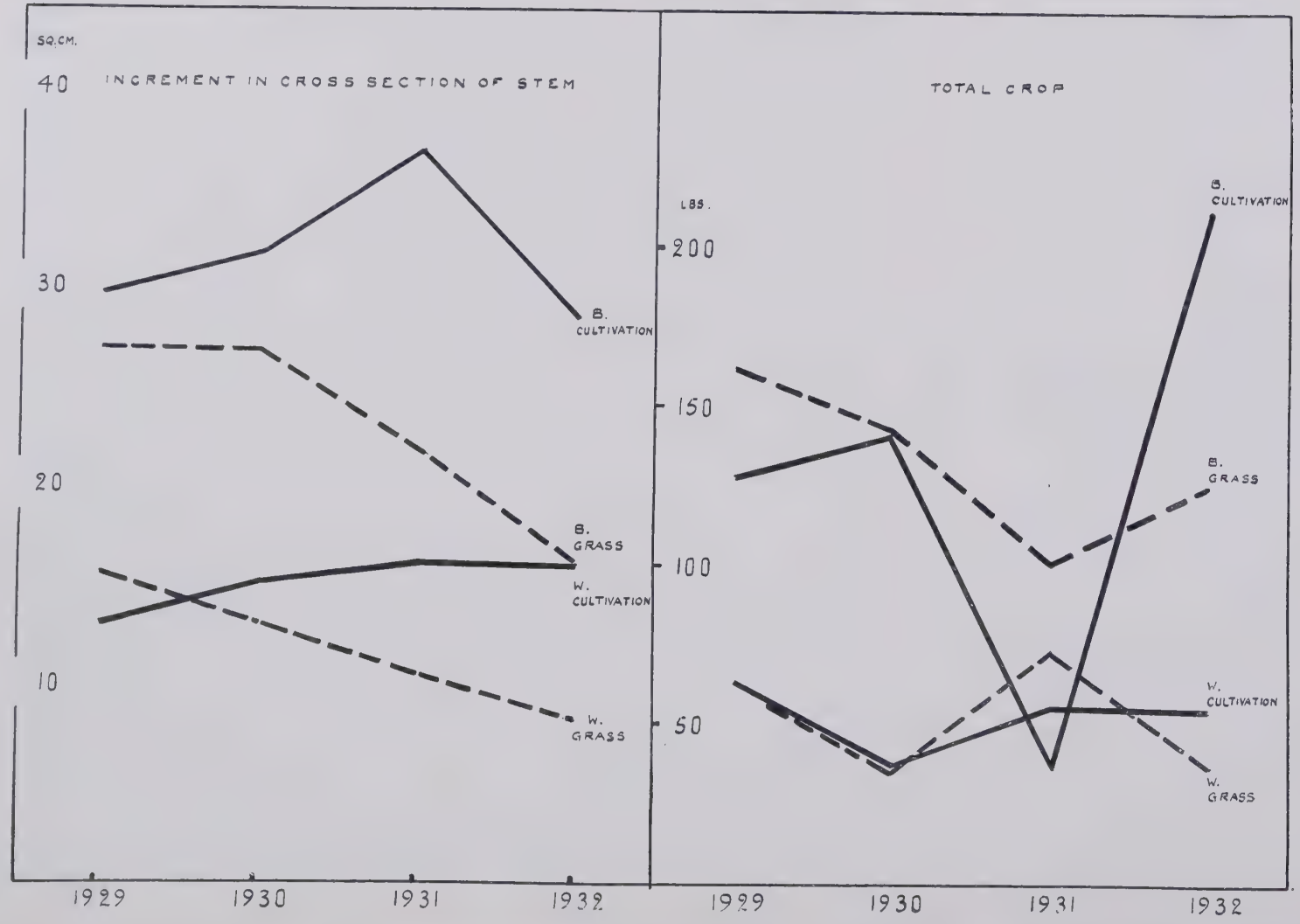


FIG. 7.

it seems likely that the result was due in part to the actual dying of fruiting spurs, as a result of nitrogen deficiency, since Worcester Pearmain is not usually a biennial bearing variety.

The yellowing of the foliage and early defoliation of the trees on the grass plot, which first showed itself in the Autumn of 1930, was very evident in August, 1931. At that time the trees under cultivation all showed dark green foliage. On the grass plot there were definite differences connected with rootstock, the more dwarfing stocks showing very much more yellowing than the vigorous. As an illustration of this, Bramley's Seedling on Nos. IV, VII and IX had from 60 to 80 per cent. yellow leaves, while trees on such stocks as Nos. I, XII and XVI still had at least half their leaves dark green.

In the following season differences in leaf colour and defoliation were even more marked. By October 27th all the leaves of Worcester Pearmain under grass were yellow, and some 40 to 60 per cent. of the leaves of this variety had fallen, while those on the cultivated plot had for the most part barely started to turn colour. A fortnight later, the trees on the grass plot were completely defoliated, whereas under cultivation only about two-thirds of the leaves had dropped. On both plots trees on the more dwarfing and heavy cropping stocks, such as Nos. IX, IV and VII, again dropped their leaves first.

In Bramley's Seedling leaf colour differences, though not so marked as in Worcester Pearmain, were quite distinct and the trees under grass dropped their leaves at least a week earlier than those under cultivation. It must be remembered that the cultivated plot was laid down to grass in this year, but that, owing to the sparse herbage obtained, little effect on the trees was to be observed. It should be noted that, probably owing to the regular dressings of potash applied until 1932, there was little sign of leaf scorch on either plot.

The very obvious dying out of fruiting spurs of the grassed plot in 1932, though evident to the eye, was extremely difficult to measure; and though a technique for measuring differences in leaf size and number and the classification of various types of shoot is in the process of development, it was not possible to use it on these plots.

Fruit Colour.

The fruit from the Worcester Pearmains on certain stocks on the two plots was graded for amount and intensity of colour in the years 1931 and 1932 and that of Bramley's Seedling in 1932.

In 1931, in connection with the Kent Fruit Soils Survey (2), an intensive investigation into the colour effect on these two plots was made for Worcester Pearmain on Nos. I, II, V, IX and XVI, and the following conclusions were arrived at.*

1. Fruit from the grassed plot was undoubtedly better coloured than that from the cultivated one.
2. On the whole, fruit from trees on Nos. I and IX was better coloured than that from Nos. II and V, while that from trees on No. XVI was poorest; but whereas on the cultivated plot, trees on Nos. II and V did not differ from those on No. XVI, on the grassed plot they did not differ from those on Nos. I and IX, showing that trees on Nos. II and V were affected to a greater extent by the grass than those on No. XVI.

* The authors are indebted to the Fruit Soils Survey Committee of the Ministry of Agriculture for permission to include these results.

In order to find how far the differences given above could be shown by taking into consideration surface area coloured only, a separate examination was made with this object. It showed that, while with one exception the same differences were obtained, they were not so marked as where intensity of colour was taken into consideration.

The exception was No. XVI which, while it showed the effect of grassing down in its brighter colour, did not show the added surface area coloured, which was quite definite on other stocks.

It was noted that the effect of size of crop on fruit colour was less under grass than under cultivation, for on the latter plot the trees which had the largest crops had the most colour, but this was not so, except on No. XVI, on the grass plot. Further, this effect was not shown to any extent on trees on No. IX on either plot.

These records were repeated in 1932, but unfortunately the trees on Nos. I and II from the grass plot could not be included. However the records on Nos. V, IX and XVI bear out those taken in 1931 very closely.

The average colour figures obtained in the same way as those in Part I of this paper are given for the two years in Table VIII.

TABLE VIII.

AVERAGE FRUIT COLOUR FIGURE FOR WORCESTER PEARMAIN.

Stock No.	I		II		V		IX		XVI	
	1931.	1932.	1931.	1932.	1931.	1932.	1931.	1932.	1931.	1932.
Grass	1·9	—	2·1	—	2·7	2·9	1·3	1·6	5·9	4·8
Cultivation	4·6	3·8	8·4	7·9	7·2	6·9	3·9	3·6	7·1	6·0

The colour grading of the Bramley's Seedling in 1932 revealed the same striking differences both in amount and intensity of colour between the two plots, for while the apples on the cultivated plot showed the normal green colour associated with this variety, those under grass were for the most part bright crimson with a yellowish ground colour. The colour grading figures calculated for apples from trees on rootstocks Nos. I, II, V and VII showed that the majority of the fruit from the grass plots was more than half coloured and of high intensity, while those with the most colour from the cultivated plot (i.e. on No. I) had little more than a quarter of the surface coloured and that of low intensity.

Fruit Size.

Table IX shows the effect of the grass on the size of fruit of Worcester Pearmain in 1931 and 1932, and Bramley's Seedling in 1932, as expressed by the average number of apples to a bushel of 40 lbs. The Bramley's Seedling in 1931 are not included owing to the small crops in that year. Although this method of showing fruit size is open to criticism since the density of the apples may be altered by treatment, there is reason to believe that this will have a comparatively minor effect.

TABLE IX.

EFFECT OF GRASS ON SIZE OF FRUIT AS SHOWN BY THE AVERAGE NUMBER OF APPLES TO A BUSHEL (40 LBS.).

Stock No.	1931.		1932.			
	Worcester Pearmain.		Worcester Pearmain.		Bramley's Seedling.	
	Cultivation.	Grass.	Cultivation.	Grass.	Cultivation.	Grass.
IX	200	214	196	241	103	118
IV	205	220	203	229	130	135
II	184	201	186	217	117	118
V	207	192	217	205	151	119
I	206	213	194	215	123	115
XVI	191	182	198	181	116	112

For Worcester Pearmain, with the exception of apples from Nos. V and XVI, all show the effect of grass in reducing fruit size in both seasons and a larger difference in 1932 than in 1931. Bramley's Seedling on No. IX under grass had much smaller fruit than under cultivation and that on No. IV also was smaller, but on the other stocks there is no sign of deterioration.

The behaviour of the two stocks Nos. V and XVI is very interesting. No. V is well known to produce inferior fruit as compared with other rootstocks with most varieties and here, under cultivation, the fruit is indeed the smallest; yet under grass the fruit is not abnormally small.

Trees on the very vigorous No. XVI have been shown already to be less influenced by grass in other ways and apparently fruit size has not been influenced either.

It is evident that trees on the more vigorous rootstocks have taken longer to feel the effects of grassing than those on the more dwarfing stocks.

This may possibly be an indirect effect of rootstock since the grass has made considerably less growth in the dense shade under the trees on the more vigorous rootstocks.

THE EFFECTS OF NITROGENOUS MANURING.

(*a*) *Worcester Pearmain.*

In the Spring of 1933 the attempt was begun to restore the vigour of the Worcester Pearmains, which had been under grass since April, 1930, by applying dressings of nitrogen in the form of nitro-chalk. The problems to be faced were firstly to put on enough nitrogen at the right time of year, so that it would not all be absorbed by the grass; and secondly to obtain some idea of the quantity required to maintain the balance between vigour and fruit quality.

The trees available did not permit of more than two treatments. In the first year the most important problem seemed to be to get the nitrogen to the trees. There was reason to believe that the usually recommended dressing of 5 cwt. per acre would not be sufficient to restore the vigour of trees badly deficient in nitrogen, such as these, at any rate in one year. It was therefore decided to go to extremes and compare the effect of the usual dressing with that of a very heavy application to see if the restoration could be thus accomplished in a single season. In 1933, therefore, 5 cwt. and 15 cwt. of nitro-chalk per acre were the two treatments decided upon. It was not possible to try different

The Effect of Nitrogenous Manuring on Worcester Pearmain after Three Seasons under Grass.
Average of Thirteen Rootstocks.

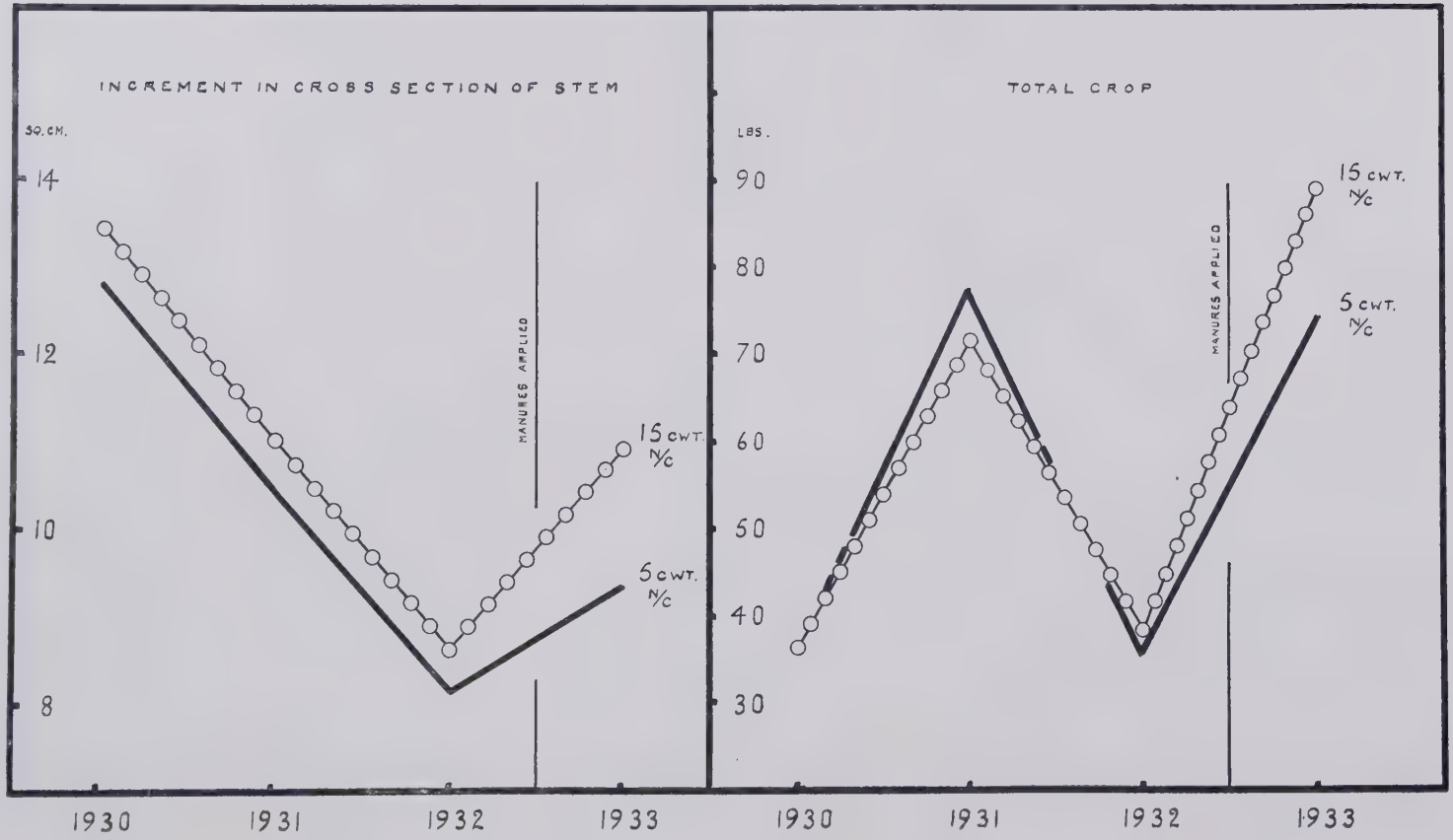


Fig. 8.

times of application in this preliminary trial, but the nitro-chalk was applied half in February and half immediately the first flush of grass had been cut.

The Bramley's Seedling on this plot were used as buffer trees for the time being, and the fertilizer was applied over a strip of 15 ft. wide centred on the row of Worcester Pearmains, there being 6 ft. unmanured between parallel strips.

The effect of the nitro-chalk on growth as shown by increment in cross section of stem and total crop in the season immediately following the applications is shown in Fig. 8. It is very evident that both dressings caused an increase in stem thickening, this being further evidence in favour of nitrogen being a limiting factor for this growth character. Previous to manuring, and since the trees were put down to grass, there was a steady fall, which was quite independent of size of crop. In 1933, however, there was a definite rise in spite of a very much greater crop than in 1932. Those trees which had the heavy dressing certainly had a somewhat greater increase in this respect, but it seems most probable that both dressings had a definite effect. In addition, the trees having 15 cwt. had a heavier crop than those getting 5 cwt., and if this difference is compared with the three previous years' cropping, it seems most likely that it is not due to mere chance. In addition, it may be stated that in practically every case the trees on the thirteen rootstocks, of which these figures are the average, confirm the mean of the whole.

At first sight this result might be expected to be merely due to fruit size, but this is quite definitely not the case ; for the fruit from the heavily dressed trees was in all cases the smaller of the two. The fruit was graded for size into five size grades, from 1 to 5, grade 1 being the largest, and Table X shows the mean size grade for each of six representative rootstocks and the mean of the whole.

It appears therefore that this extra crop must be connected with an increased set of blossom.

TABLE X.

EFFECT OF NITROGENOUS MANURING ON SIZE OF FRUIT OF WORCESTER PEARMAIN.

On Rootstock No.	IX	II	V	I	XVI	XII	Mean.
Nitro-Chalk at 15 cwt. per acre ..	3·2	3·0	3·2	3·0	2·7	3·4	3·08
5 cwt. per acre	2·9	2·7	3·0	2·7	2·4	3·3	2·83

The effect of the differential manuring on growth was very much more evident in shoot growth, leaf colour and earliness of defoliation than upon stem thickening. It was soon obvious that the trees receiving the heavy dressing were making much more shoot growth and had very much darker leaves than the less heavily dressed trees. Surveys for leaf colour and time of defoliation were made in September and November. In every case the leaves on the 5 cwt. trees turned yellow much earlier and dropped sooner. On November 7th all these trees had dropped about 50 per cent. of their leaves. At this time the 15 cwt. trees were for the most part still green and in no case were they defoliated more than 40 per cent. It is an interesting fact that though the trees on the most vigorous stocks were the greenest at this time, they had dropped a considerably greater proportion of their leaves than those on the more dwarfing stocks ; this tendency was already evident by September 23rd. How far this was a result of overcrowding

and consequent competition for moisture, or possibly leaf scorch, in this exceptional drought season, it is difficult to say.

Although the heavy dressing had a much greater effect in restoring the vigour of these trees and even apparently increased the total crop, the effect on fruit colour and quality was disastrous in the first season.

Owing to severe hailstorms in June, 1933 was not a good season for comparing fruit quality from the market point of view, since there was practically no "Extra Fancy" fruit anywhere on the Station. Nevertheless, the fruit from these plots was graded into three market quality grades, "Fancy", "C" grade and culls, to try to show the effect from the marketing point of view, and was further graded for amount and intensity of colour as previously described. Table XI gives the results of these gradings

TABLE XI.

EFFECT OF NITROGENOUS MANURING ON COLOUR OF FRUIT OF WORCESTER PEARMAIN.

On Rootstock No.	IX	II	V	I	XVI	XII	Mean.
	AVERAGE COLOUR FIGURE.						
Nitro-Chalk at 15 cwt. per acre ..	5·3	4·7	6·1	5·0	6·0	6·7	5·6
5 cwt. per acre ..	2·9	3·1	3·7	2·8	5·6	5·0	3·9
	PER CENT. OF CROP "FANCY" GRADE.						
15 cwt. per acre ..	41	42	49	29	48	26	39·3
5 cwt. per acre ..	58	66	57	61	50	41	55·6

as shown by average Colour Figure and proportion of fruit in the "Fancy" grade for fruit from six representative rootstocks. It will be seen at once that the colour on the 15 cwt. trees was very much poorer than on the 5 cwt. trees, and this is reflected in the lower percentage in the "Fancy" grade, for while 55·6 per cent. of the fruit was marketable under this quality grade in the latter case, only 39 per cent. was so marketable in the former. It is noticeable that there was less difference in colour on the strong rootstocks, especially No. XVI, but this was once again most probably due to shade, for this part of the plantation was very crowded.

This does not quite tell the whole story, for the two batches of fruit were marketed in separate consignments on the same days; and *within the same quality and size grades* fruit from the 15 cwt. per acre trees always fetched about a shilling per bushel less than the others, and this was due to their poorer appearance and lack of firmness.

This experiment will be continued for a three year period. In the second and third seasons those trees which had 15 cwt. per acre will be left unmanured, while those which had 5 cwt. will continue to receive the same amount annually. It should then be seen whether the shock tactics employed in the first year will justify the loss of fruit quality in that season by increased crops in the second and third, or whether the milder treatment will in the long run show the more profitable result.

(*b*) *Bramley's Seedling.*

On the neighbouring plot the trees of Bramley's Seedling were put down to grass in the Spring of 1932, but the grass grew poorly in that season, without showing any obvious effect on the trees. The problem here to be solved was an entirely different one, for as the trees were still in a vigorous state, the object was to check their vigour by the

grass without allowing them to become starved of nitrogen, as had been the case with the neighbouring plot.

Accordingly, the plot was once again divided in such a way that half the trees on each stock received 5 cwt. of nitro-chalk per acre in two dressings, as already described, while the rest were left unmanured as a control. The method of application was the same as before, though there were no guard trees on this plot, the Worcester Pearmains having been removed.

Bramley's Seedling in 1933 were in their " off " year for cropping and there is no evidence to show any effect of the nitro-chalk on total crop. The difference in stem thickening was also small, but on the whole slightly in favour of the manured trees. Nevertheless, by late Summer, differences in colour of foliage were quite obvious, it being easy to pick out the unmanured trees by their yellow leaves, and by the beginning of November these differences were very marked. On the 17th and 25th of November, surveys for amount of defoliation were made and show quite clearly that the unmanured trees were considerably earlier in leaf fall than those which received the nitro-chalk. The photographs in Figs. 9 and 10, which were taken on 8th November, show the difference very clearly. In Fig. 9, an unmanured tree is shown in the foreground, while a manured tree appears in the background, while in Fig. 10 the reverse is the case. In leaf colour there was once again less difference in the trees on the more vigorous rootstocks, though in time of defoliation they appeared to behave very much as the others.

Owing to the smallness of the crop, detailed records for size and colour of fruit were not made, but it was noticeable that the fruit from the unmanured trees was considerably yellower and had more red colour than the rest. When the fruit was taken out of cold store for marketing in January, this difference in appearance was more marked, while the fruit from the unmanured trees was definitely brighter and more free from blemish.

These treatments will be continued for a further season until more definite differences begin to appear.

Discussion.

The laying down to grass of eleven-year-old trees of Bramley's Seedling and Worcester Pearmain, without nitrogenous manuring, resulted in a very large measure of nitrogen deficiency in the third season, though this was not so marked in the trees on the very vigorous varieties of rootstock as upon the more dwarfing and heavy cropping varieties. There was a definite falling off in growth during the three years, and though in the second season the crop under grass apparently was increased, in the third there was considerably less fruit than on the cultivated plot. This was probably connected with the dying out of fruiting spurs. There were large differences between the plots in fruit colour and in colour of leaves and time of defoliation. In all these characteristics the effect of grass was less well marked in trees on such very vigorous stocks as Nos. XVI and XII, possibly owing to the less vigorous growth of the grass itself.

Applications of nitro-chalk given in 1933, which it must be remembered was an exceptionally dry season, evidently had an immediate effect on the trees. On the Worcester Pearmains, which had been under grass for three seasons, the effect of a dressing of 15 cwt. per acre on growth was very marked, though the quality of the fruit was ruined; the lighter dressing of 5 cwt. per acre apparently had an effect on stem thickening but not on the other aspects of growth and the fruit remained of good quality. On the Bramley's Seedling under grass for one season only a light dressing of 5 cwt. per acre had a marked effect on leaf colour in the Autumn, and considerably delayed defoliation.

GENERAL APPLICABILITY OF RESULTS.

A question that naturally arises is the extent to which the results of these manurial experiments, both under cultivation and grass, are applicable to fruit within the county and, indeed, throughout the whole country.

Fortunately the survey of the soils and fruit of the Lower Greensand, a report on which is shortly to be published (5), has thrown much light on the distribution in the county of soils similar to that at East Malling.

Most of the soil at the Research Station is derived from freely drained, light textured river drift overlying the calcareous Hythe Beds. This drift extends over a considerable area elsewhere, though the depth of the deposit may be considerably greater at Malling and the " pug " be absent. This " pug " is a pronounced layer of clay and humus deposited at the junction of the drift and the Hythe Beds. Being rich in available plant food and very retentive of moisture, its presence would be expected to have a marked effect on tree growth and in fact it has been shown that roots are concentrated in it to a marked extent (10). In spite of the importance of the "pug" it is probable that the results of the experiments described in this report are applicable to the other series of the drift. The need for dressings of potash on the lighter soils is even greater than at East Malling, while in orchards the effect of the grass, unless adequately counteracted by nitrogenous manuring, would be more harmful.

Moreover, of the series derived from the Hythe Beds, the Medway is in many respects similar to the Malling occurring at the Research Station and is widely distributed. In addition, experience gained on the Survey suggests that while some of the Lower Greensand series may not be deficient in potash, there are very few on which potash applications have not had a good effect and indeed in many cases successful growth of certain kinds of fruit is dependent on attention to this point.

It was shown also that only 50 per cent. of the apple plantations were cultivated and observation in many of those under grass suggested that nitrogen deficiency was a problem needing serious consideration.

It is believed, therefore, that the applicability of these experiments is not restricted by local conditions and that the problems that are being examined are similar to those of many growers in Kent and, indeed, other parts of the country where conditions of soil and rainfall are similar.

As is invariably the case at East Malling, in any piece of pomological research, a large number of workers have taken part at one time or another ; and without their help and the constant interest and advice of the Director, who initiated these experiments, it would not have been possible to produce this paper. The authors would like, however, particularly to acknowledge their indebtedness to Dr. T. Wallace and Dr. R. C. Knight for kindly reading the manuscript and offering many valuable comments thereon. They would further like to thank Mr. G. A. Cowie of the United Potash Company for permission to reproduce the photographs in Figs. 3 to 6 which were taken by him.

Summary.

1. Experiments in the manuring of Bramley's Seedling and Worcester Pearmain apple trees on different rootstocks during the seasons 1930-33 are described.

2. Twelve-year-old trees growing under cultivation and unmanured since planting were subjected to heavy dressings of sulphate of ammonia and sulphate of potash.

FIG. 3.

Fourteen-year-old Bramley's Seedling—unmanured since planting. Note growth practically ceased—not so much bare wood as in Fig. 4.

FIG. 4.

Fourteen-year-old Bramley's Seedling—unmanured for twelve years. Sulphate of Ammonia applied in last two seasons. Note very little extension growth—much bare wood due to leaf scorch.

FIG. 5.
Fourteen-year-old Bramley's Seedling—unmanured for twelve years. Sulphate of Potash applied in last two seasons. Note much new extension growth.

FIG. 6.
Fourteen-year-old Bramley's Seedling—unmanured for twelve years. Sulphate of Potash and Sulphate of Ammonia applied in last two seasons. Note: The most marked difference between this and Fig. 5 at this time was in leaf colour.

FIG. 9.

Bramley's Seedling. No Nitro-Chalk. 5/11/33.

FIG. 10.

Bramley's Seedling. 5 cwt. Nitro-Chalk. 8/11/33.

3. The dressing of sulphate of potash effected a remarkable recovery in shoot-growth, amount of crop and size and quality of the fruit in the second season. Nitrogen by itself was generally detrimental, with potash it further increased the growth and cropping but always reduced fruit colour.

4. Though these results were generally true for the majority of rootstocks, there were certain exceptions, especially with Worcester Pearmain.

5. Two plantations, one of which was grassed down in 1930 and the other cultivated, were compared for three years—nitrogenous manures being withheld from both. Growth fell off very markedly on the grass plot, and though in the second season there was an increase in crop, there was a definite decrease compared with the cultivated plot in the third. The fruit from the grass plot was of exceptionally high colour. These results were more marked on the less vigorous rootstocks.

6. A very heavy application of nitro-chalk after three seasons under grass, had an immediate effect on the growth of Worcester Pearmain but ruined the quality of the fruit. A lighter dressing had little effect on shoot growth and the quality of the fruit was maintained.

7. The effect of a light dressing on Bramley's Seedling, which had been one season only under grass, was evident in the dark green leaves in the Autumn and delayed defoliation.

Bibliography.

(1) Amos, J., Hatton, R. G. and Hoblyn, T. N. "The Response of Apple Trees on known Rootstocks to Applications of a Complete Fertilizer." Ann. Appl. Biol., 1930, **17**.

(2) Bane, W. A. and Gethin-Jones, G. H. "Fruit Growing Areas on the Lower Greensand in Kent. A Survey of the Soils and Fruit, 1928-31." Ministry of Agriculture & Fisheries. In the press.

(3) Grubb, N. H. "An analysis of the effect of Potash Fertilizers on Apple Trees at East Malling." Journ. Pom. and Hort. Sci., 1928-9, **7**, 32-59.

(4) Palmer, R. C. "Recent Progress in the Study of Jonathan breakdown in Canada." Sci. Agric., 1931, **11**, 5.

(5) Rogers, W. S. "Rootstock effect on Colour and Size of Apples." E. Malling Res. Sta. Ann. Rep. for 1926 (March, 1927) (II Supplement).

(6) Rogers, W. S. and Vyvyan, M. C. "Root Systems of some ten-year-old Apple Trees on Two Different Rootstocks and their Relation to Tree Performance." E. Malling Res. Sta. Ann. Rep. for 1926-27 (II Supplement), Oct., 1928.

(7) Ridgway, R. "Colour Standards and Colour Nomenclature." Hoen, Baltimore, Md.

(8) Wallace, T. "Pot Experiments on the Manuring of Fruit Crops." Long Ashton Res. Sta. Ann. Rep., 1921.

(9) ——— "Pot Experiments on the Manuring of Fruit Trees." Long Ashton Res. Sta. Ann. Rep., 1922.

(10) ——— "An experiment on the Winter Killing of Vegetable Crops in Market Gardens." Journ. Pom. and Hort. Sci., 1926, **5**, 205.

(11) ——— "Factors influencing the Storage Qualities of Fruits." Pro. First Imp. Hort. Conf., Part III, 9, March, 1931.

(12) ——— "Problems of Fruit Tree Nutrition." Imp. Bur. Fruit Prod. T.C.4, 1933.

ROOT STUDIES IV

A method of observing root growth in the field; illustrated by observations in an irrigated apple orchard in British Columbia

By W. S. ROGERS

STUDIES of root systems carried out by excavations at this Research Station and elsewhere have given some information as to the position and distribution in the soil of the roots of fruit plants. Such studies do not, however, show exactly when the roots grow, nor how they respond to the seasonal changes of soil conditions.

In order to gain some information on these matters a preliminary attempt was made in 1930* to grow young apple trees in root observation boxes which had a sloping glass side against which the roots grew. As this technique proved successful it was decided in 1931 to adapt it to the observation of the root growth of mature trees in the orchard, and accordingly a root observation trench as described below was constructed and installed against a thirteen year old apple tree on a No. I rootstock at East Malling.

It was found that the roots grew readily along the glass observation windows, and that it was possible to observe and record the time, position and amount of new root growth. It was also possible to observe the suberization of the root, the formation of lateral roots, and the ultimate death or survival of the root. By means of a microscope the root hairs could be watched, and photo-micrographs could also be obtained.

It was realized that soil temperature and moisture were very important factors in connection with the root growth, and attempts were made to record these factors.

In 1932 three more trenches were installed at East Malling, two beside trees on rootstock No. IX and one beside a tree on rootstock No. XVI. These four trenches at Malling therefore form a series covering the range of rootstocks from very dwarfing (No. IX) to very vigorous (No. XVI). Three years' records of root growth are available in the case of the No. I and two years' records in the other cases. This information is now being summarized into a separate report.

In the same year the opportunity occurred for the writer to continue his root study work for a year at the Dominion Experimental Station, Summerland, British Columbia—under a scheme for the exchange of research workers within the empire, arranged by the Empire Marketing Board. This provided an ideal opportunity for the study of root growth under controlled soil moisture conditions, since Summerland is in the Dry Belt and all the fruit there is grown by artificial irrigation.

An observation trench was installed against a sixteen-year-old McIntosh tree on seedling roots in the Spring of 1932, and the first season's results will serve to demonstrate the working of the technique.

The writer tenders his grateful thanks to the authorities of the Dominion Experimental Station for placing facilities at his disposal for the installation and working of this trench at Summerland.

* Reference is made to this work in East Malling Research Station Ann. Rept. for 1930, A13, p. 41, and subsequent Annual Reports.

Construction of the Observation Trench.

Since much of the success of the method depends on the way the window is installed, this will be described fairly fully.

A strong steel framework supports $\frac{1}{4}$ in. plate-glass windows vertically against the soil about 2 ft. 6 ins. from the trunk of the tree. The glass area is about 4 ft. high and 3 ft. wide, but is divided into six main divisions, each of which has a separate light-proof wooden shutter. The window is housed in a wooden cabin about 8 ft. long, 4 ft. wide and 5 ft. deep sunk in the soil. It has steps at one end, and a roof hinged to open, as shown in Fig. 1. The joins are fitted with light traps.

In order to get the soil properly in contact with the glass the following procedure is necessary. First the hole is dug for the cabin ; the vertical soil wall against which the window will go is left intact an inch or so further from the tree than the position the window will occupy. The next 3 ins. of soil is then carefully removed in layers corresponding to differences of soil profile—the top soil, subsoil and so on. This soil is spread out in labelled boxes to become nearly air dry, since it cannot be packed against the glass when wet without causing smearing and puddling. When dry the soil is sifted through a fine sieve to remove stones and caked lumps.

Any roots that are found are either removed, or if desired are kept intact to be placed across the glass window. In the case quoted a few small roots were retained and packed in the soil against the window at their original depth.

The window frame is next fixed firmly in position, supported independently of the trench walls. A screw adjustment for pressing the frame against the soil is useful. The bottom panes of glass are placed in the framework, and should then be about 2 ins. away from the fresh soil surface. The dry soil is then carefully packed in between the glass and the fresh soil wall, in layers corresponding to the original soil layers. The soil is firmed down with a wooden strip so that it occupies the same volume as before. When the bottom half is nearly full the top panes are added and the filling is continued to the top. If this is properly carried out the result will be an accurate soil profile in good contact with the glass. The soil moisture will gradually spread to the glass, and new root growth will probably reach the glass within about four weeks if the trench is installed in Spring.

The glass used was " Pilkingtons wired Georgian plate " which contains a network of wires forming half inch squares within the glass. The squares were numbered across and down the window, for easy reference to a root growing in any position, and they enabled accurate drawings of new root growth to be made on squared paper. Ordinary $\frac{1}{4}$ in. plate glass can also be used, and this can be marked with squares with a writing diamond if desired.

Temperature Records were obtained from thermometers inserted through holes in the trench wall beside the observation window. At East Malling a double recording thermograph recorded the temperature at 1 ft. and 3 ft. on weekly charts.

Soil Moisture was another factor on which records were obtained. The rainfall records were taken daily, but since Summerland, British Columbia, is in the Dry Belt the precipitation was very small. Artificial irrigation was applied to the orchards at a known rate by the furrow method approximately fortnightly. A continuous record of moisture was obtained by the use of the " dryness meters " developed at East Malling. These meters record the " capillary pull " of the soil, which increases as the soil gets drier. In their simplest form they consist of a special porous pot filled with water placed at the desired depth in the soil and connected by a water filled tube to a mercury manometer. As the soil dries the mercury rises, and when the soil becomes wetter the mercury falls. Since the capillary pull also depends on the fineness of the

soil particles each instrument must be calibrated if it is desired to read direct percentages of moisture. Fuller details of this instrument will be given in a report at present in preparation.*

Records Taken.

At regular intervals the trench was opened and the shutters were removed one by one, exposing the roots to view. The new growth was drawn and dated on the root plan. In later records the length of each individual root extension, with the square which contained it, and the total white length of each root was recorded in tabular form at the same time. This made summarizing easier, since it gave at once the total number of growing roots, their extension, and the total white length visible on the glass.

Results.

The growing roots of the apple are white in colour, and have very short root hairs. After a period of about a fortnight to a month the root begins to suberize, the root hairs shrivel up, and the cortex goes brown. The shrivelled brown cortex later becomes subject to insect, fungus or bacterial action, so that it often disappears, leaving the central stele exposed. This is naturally quite loose in the original hole that the root made.

Both new and suberized roots can be seen in Fig. 2, which shows part of one of the observation windows at Malling.

Figs. 3 and 4 are photo-micrographs of a root at Summerland.

Fig. 3 shows the new white root, with the root cap (A) elongating region (B) and behind it the region with root hairs (C). The white object (D) is an eelworm. Numerous insects and nematodes can often be seen in the soil and on the roots.

Fig. 4 shows the same piece of root twenty-five days later, when it has suberized but before the cortex has rotted away.

The root growth is sometimes quite rapid. For instance the root shown in Figs. 3 and 4 grew 3·2 inches in fourteen days. It was growing almost vertically downwards at a depth of about 3 ft. below ground level. (It is placed horizontally in the illustration for convenience.)

The correlation between various measured factors is seen in Fig. 5, which shows number of growing root tips and mean daily root growth as recorded twice weekly on the observation window; shoot growth, the mean length of five sample shoots measured weekly; soil temperature at 2 ft.; soil dryness, as shown by capillary pull at 1 ft. and 3 ft. measured daily; and irrigation and rainfall.

The action of the soil dryness meter should first be noted. As the soil dries out through evaporation and the action of plant roots the capillary pull increases, as shown by the rising lines on the graph. When irrigation is applied as on 13th June the capillary pull decreases, and the falling lines on the graph show that the water continues to percolate from the saturated area next the irrigation furrows to the less saturated parts of the soil (the dryness meter was placed 18 ins. on one side of the furrow, for two or three days. The drying out then continues again, to be followed by a new wetting at the next irrigation. The irrigations of 3 ins. to 5 ins. of water penetrated to the lower meter at 3 ft., but a rainfall of 0·27 ins. on 10th July is seen only to have affected the 1 ft. meter. Similarly another fall of rain on 12th August only reached 1 ft. Irrigations were applied at intervals of about a fortnight, but in August irrigation was withheld from this tree, resulting in a very great drying out of the soil both at 1 ft. and 3 ft.

* This will probably appear in the *Journal of Agricultural Science*.

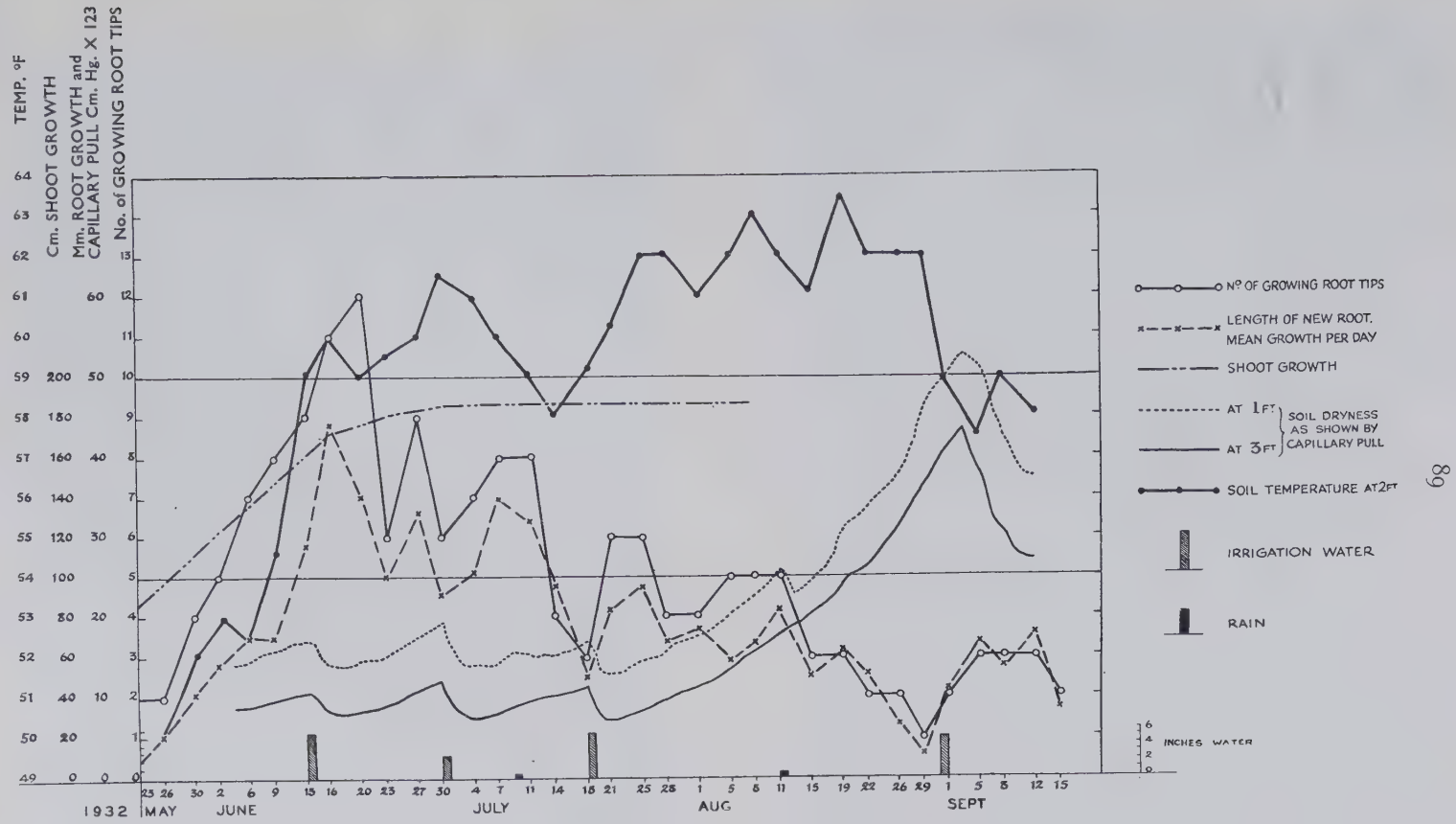


FIG. 5.

Apple Root and Shoot growth, Soil temperature and moisture in an irrigated orchard. Summerland, B.C.

When 5 ins. of water was finally applied on 31st August it did not reach the dryness meter till two days later, for the mercury actually continued to rise for two days before finally falling.

Turning to the root growth, it will be noted that as the soil temperature rose the root growth as shown in both number and length of roots increased also. The fall in temperature from 16th to 20th June was followed by a fall in root growth, and the rise in temperature in the next week was reflected in greater root growth. As might be expected, there is sometimes a lag between the temperature change and the root change, depending on the exact time and amount of the temperature variation.

In the following period, 27th to 30th June, the temperature was still rising but the number and amount of roots fell off. This is explainable by the degree of soil dryness, as shown by the dryness meters. When irrigation was applied on 31st July the number and amount of roots rose again sharply, although the temperature was falling. The fall in temperature and increase in dryness together were reflected in decreased root growth from 7th to 18th July. At this date a further irrigation allowed the roots to respond to the next rise in temperature. After this the soil got drier and drier, and although the temperature was high the root growth continued to fall off till another irrigation was applied on 31st August. The response in increased root growth was immediate and continued for a week or more, after which the falling temperature again reduced the root growth.

At this point the writer left British Columbia to return to England, and this trench was handed over to the staff of the Dominion Experimental Station.

The results shown are most suggestive, and while any conclusions drawn from such a small number of observations must necessarily be tentative, it appears likely that root growth in the field varies directly as soil temperature, provided that sufficient soil moisture is present. Any deficiency in soil moisture is reflected very quickly in decreased root growth—long before the leaves wilt for instance.

These conclusions are borne out by the observations in the trenches at East Malling, and it is hoped to present the data of several consecutive seasons' records in due course.

This report is put forward to show the possibilities of this technique, which puts a new weapon in the hands of the root investigator.

Drawbacks and Advantages of this Technique.

All methods of root study have certain limitations, and it is well to realize the limitations of this technique.

The chief drawbacks of this technique are as follows :

1. Only a small sample of the roots of the plant is seen. This can be overcome by having several trenches.
2. The placing of a trench beside an established tree causes the cutting of some large roots. For this reason the window should not be too large.
3. The observed roots are growing against a sheet of glass. This is not so unnatural as might at first be thought, since the surface of a pane of glass is really just like a large smooth grain of sand or a smooth flint.
4. The roots are exposed to light during recording. An experiment is now in progress to determine the exact effect of varying amounts of light on the roots, but it appears from preliminary experiments that the short exposures given during routine recording, do not seriously harm the apple roots.

Against these disadvantages can be placed the very large advantage that a series of direct and detailed observations as already described can be made on the roots

FIG. 1.
Root observation trench as installed at East Malling and Summerland, B.C. Two of the windows are shown uncovered.

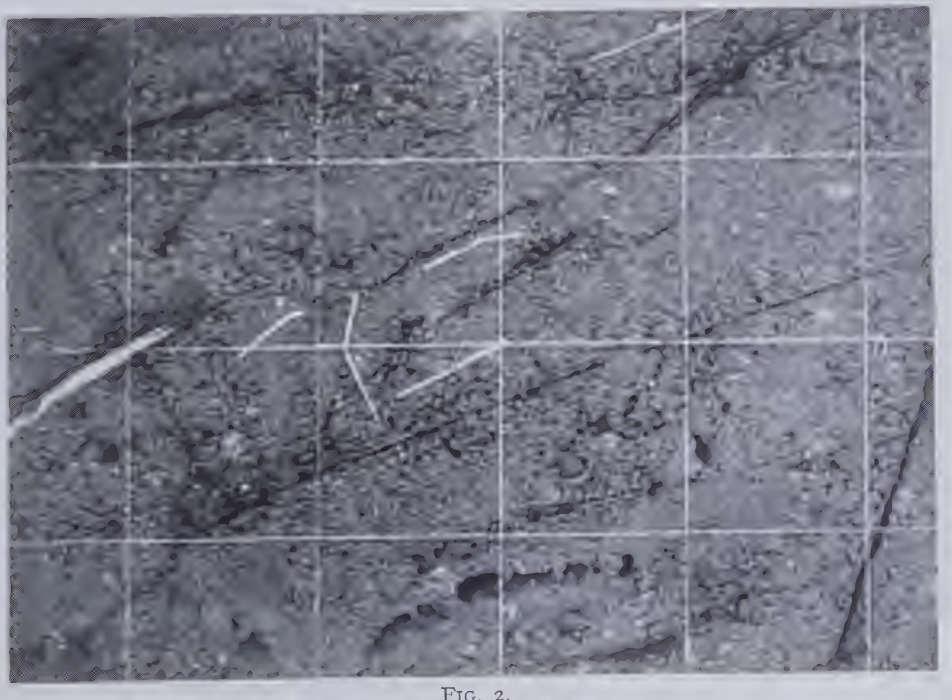


FIG. 2.
Apple roots growing along an observation window at Malling. New white roots, brown suberized roots, and older roots with sloughed cortex can be seen. A worm burrow is seen at the bottom of the picture. The white lines form one-inch squares.

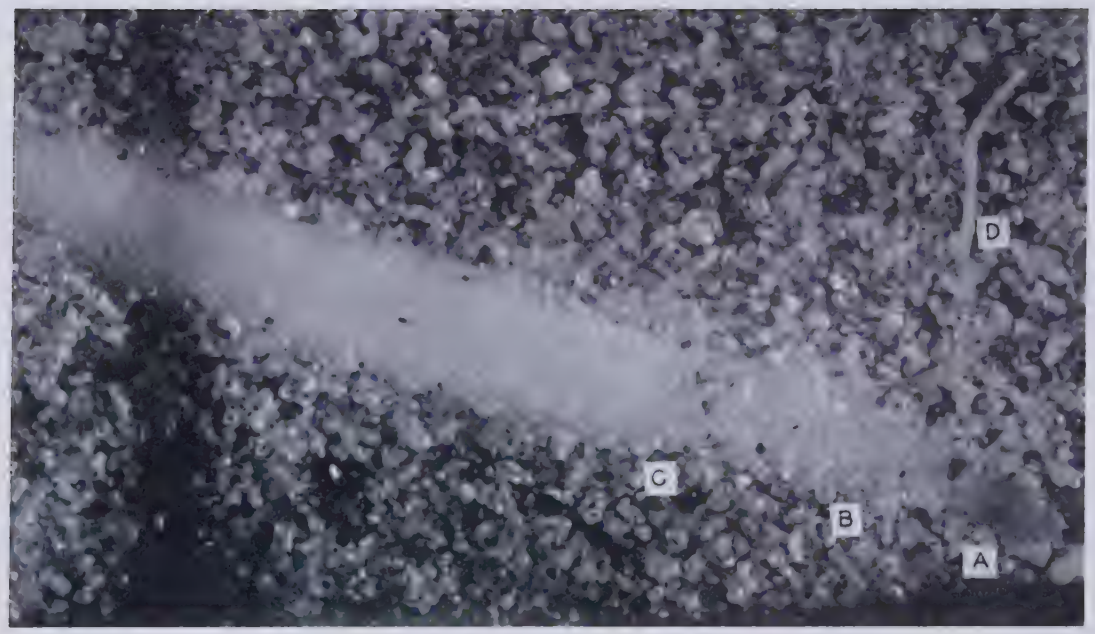


FIG. 3.
Photo-micrograph of growing root of McIntosh Red on seedling roots at Summerland, B.C. (A) Root cap. (B) Elongating region. (C) Root hair region. (D) is an eelworm. Magnification about ×15.

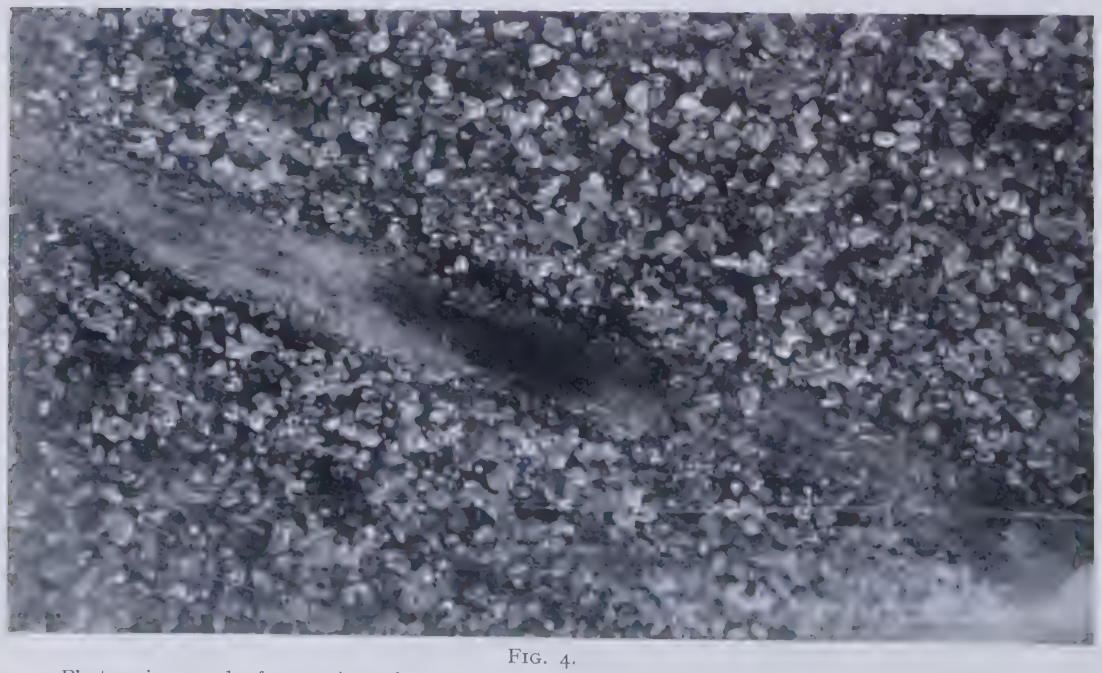


FIG. 4.
Photo-micrograph of same piece of root as above, 25 days later. Note shrinkage of root in suberizing. The root cap has grown beyond the picture.

without destroying the plant. Moreover the plant is growing in conditions very nearly approaching the normal in soil moisture, nutrient and other factors, so that it probably grows much more naturally than plants in pots, boxes or artificial media.

Many of the naturally varying factors can be measured and correlated with the root growth.

The possibilities of microscope and photo-micrographic work are also very great with this technique.

Altogether the preliminary results are most encouraging, and give rise to the hope that these windows may throw much light on the difficult problems of root growth.

Summary.

1. By the fixing of glass windows against the soil wall of a specially constructed observation trench in an orchard it has been possible to observe the growth and subsequent behaviour of apple roots.

2. The time, position, and amount of root growth can be noted, and also the suberization of the root, formation of laterals and other factors. The root hairs can be studied with a microscope and photo-micrographs can be obtained.

3. Records from an observation trench installed by the writer in an irrigated orchard in British Columbia are given. These show strong correlation between root growth and soil temperature and moisture. The root growth appears to vary with the temperature, provided moisture is sufficient. Any deficiency of moisture rapidly checks root growth.

4. A soil dryness recording instrument was used in this work. Its working is briefly described.

5. Some constructional details of the trench are given. The windows are normally covered to exclude light. The method of fixing to secure a good soil profile is described.

6. Further and more detailed observations are being obtained in four trenches, whose records now extend over three seasons at East Malling.

THE INFLUENCE OF BRANCH PRUNING OF CHERRIES ON THE GROWTH OF SUCKERS

By N. H. GRUBB AND R. C. KNIGHT

A SMALL plantation, consisting of about eighty yearling trees of Morello cherry, was set out at the end of 1923. It was extended by the planting of some thirty-six more yearlings at the end of 1924. All the trees were planted square at a distance of 12 feet in each direction.

The trees were worked on a number of vegetatively raised rootstocks ; a few trees were on two varieties of Mahaleb cherry stocks, and a few on two varieties of acid cherry stocks ; the bulk were on sweet cherry or " Mazzard " stocks, selected at East Malling chiefly on account of their ease of propagation by layering.

The soil between the trees was kept cultivated until the end of 1930 ; thereafter it was allowed to go down to grass and weeds, which were mowed several times annually.

The trees were pruned moderately, chiefly with the object of keeping the heads open and maintaining more or less bearing wood in their centres ; in this object the treatment was quite successful, there having never been any considerable amount of bare wood in the trees.

By the end of 1931, the trees being then nine and eight years old from the bud, the planting distance, 12 feet, had already proved much too close. The trees were seriously crowding each other, so that it was hardly possible to work amongst them without breaking some of the shoots or branches. It was therefore decided to " dehorn " alternate trees in each row, those in adjacent rows being arranged diagonally.

The dehorning, carried out in April, 1932, was decidedly severe, and involved, in most cases, the *removal of the greater part of the tree's head*. The larger branches were cut back to a spur or side branch near the end of the " leader " formed in the second year after planting. Smaller branches on the outside were left uncut, or were merely trimmed up to keep them off the ground. The remaining trees were thinned out, as in preceding years.

The growth resulting from the dehorning was very satisfactory, and consisted of a large number of strong shoots from the stumps of the larger branches, together with shoots of considerable vigour from the uncut smaller branches.

The sweet cherry rootstocks had already begun to sucker freely before the dehorning was done. Some stock varieties suckered considerably more freely than others, but it was observed that quite apart from differences between the various stocks, the dehorned trees as a whole had produced in 1932 more and larger suckers than the thinned trees.

An attempt was made to obtain a measure of this phenomenon but there were certain obstacles to obtaining accurate records. Owing to the spread of the roots some of the suckers beneath one tree were found to arise from the roots of the next. When two adjacent trees were on rootstocks of different species, such as mazzard and acid cherry, identification of the suckers was relatively simple, but when adjacent stocks were different varieties of the same species or even of the same variety, it became impossible to trace the origin of each individual sucker. Consequently only suckers within a radius

of 1·5 metres of the trunk of each tree were measured and these were assumed to belong to that tree. By this method a minimum number would be ascribed to the wrong tree, but of course many were neglected entirely.

The suckers were measured and grouped according to length with the result shown in Table I.

TABLE I.

LENGTH AND NUMBER OF SUCKERS FROM "DEHORNED" AND "THINNED" MORELLOS.

Age of Trees.	Treatment.	Average No. of Suckers per tree of Length :—						Total.
		cm. 0—20	cm. 20—40	cm. 40—60	cm. 60—80	cm. 80—100	cm. >100	
10	Thinned ..	3·5	8·9	4·3	0·7	0·3	0·1	17·8
10	Dehorned ..	2·5	9·4	8·4	3·8	1·8	0·9	26·8
9	Thinned ..	0·9	5·4	2·7	1·5	0·4	0·1	11·0
9	Dehorned ..	0·6	5·0	4·3	2·1	1·9	2·1	16·0

The dehorned trees produced about 50 per cent. more suckers than the thinned series and moreover, the excess is to be found among the longer individuals, the average length per sucker being greater. Thus the total length of sucker per tree shows the difference between the two series to be more marked than when numbers only are dealt with :

Average Total Length of Suckers per Tree in cm.

	ten years old.	nine years old.
Thinned	604	458
"Dehorned"	1,254	920

The length of sucker growth from dehorned trees was thus about double that from thinned trees.

This result may be regarded as an extension of the familiar effect of winter stem pruning in which the removal of one year wood normally results in the production of increased extension growth from the remaining buds. The nutrient materials available, both from storage and from root absorption, which in an unpruned tree are distributed among the growths from a large number of growing points, and over the whole cambial region producing secondary tissues, are restricted in the pruned tree to a reduced number of developing shoots and a smaller cambial area. A natural result is greater extension growth, and when the number of growing points is reduced to the extent of removing most of the head of the tree as in the case of the cherries under discussion, it is to be expected that the stem growing-points represented by the potential suckers should receive a greater proportion of the facilities for growth.

The extreme example of this is when a tree is roughly grubbed and profuse suckering follows from the roots remaining in the ground.

SUMMARY.

Very severe branch pruning ("dehorning") of Morello cherries was followed by an increase of sucker growth of approximately 100 per cent.

THE TESTING OF NEW VARIETIES OF APPLE ROOTSTOCK

A PROGRESS REPORT

By H. M. TYDEMAN

The raising and testing of new varieties of apple rootstocks has been a definite part of the work of this Station for a number of years. The seedlings which are being raised are the outcome of a joint programme of breeding work between the John Innes Horticultural Institution and this Station. While the raising of seedlings from controlled matings among the established varieties of apple rootstocks has proved a relatively simple matter, it quickly became apparent that the investigation of the potentialities of these seedlings as possible new rootstocks would prove a difficult and protracted undertaking. The crosses are being made with a twofold object. In the first place it is desired to raise a race of apple rootstocks which will combine the qualities of a good rootstock with immunity to attack by Woolly Aphis. To effect this, work has largely been concentrated upon crosses between Northern Spy and various members of the Malling Series of Paradise Apple Rootstocks. In the second place crosses have been made between rootstocks of known good performance in the hope of combining their characters. Here, immunity to disease has been incidental to the production of new rootstocks of high economic merit. The subsequent testing of families raised under these two sections of the programme has differed only in the fact that families raised for the purpose of the first section have been subjected to artificial inoculations with Woolly Aphis and that only those surviving these tests have been passed on for further trial. Further details of this work may be found elsewhere (1). The subsequent testing of the seedlings falls naturally under two heads. In the first place they are planted out in the nursery and subjected to the method of vegetative propagation known as " stooling ". The seedlings are then rigidly selected with regard to their response to this method, only those being retained which show promise of being easily multiplied by vegetative means. Those seedlings which survive this test are then raised in quantity and worked with a variety which serves as an index to the rootstocks' potential vigour and precocity. In practice Lane's Prince Albert is the variety used since it has the reputation of coming to maturity early and is the variety upon which most of Hatton's deductions upon the Paradise Apple Rootstocks have been based. It is with this latter aspect of these trials that this paper is chiefly concerned.

In the present state of our knowledge it is quite impossible to make any reliable deductions as to the subsequent influence of a seedling rootstock upon a scion variety from its appearance prior to being worked. An attempt to find morphological characters sufficiently distinctive to make it possible to correlate them with the ultimate performance of the seedling as a rootstock is described elsewhere (2). The extreme lack of discontinuity in most of the characters studied makes it seem unlikely that this method will ever prove very successful. There is promise that the plant physiologist or biochemist may, in due time, evolve criteria by which the relative capacity of a seedling

rootstock to impart vigour or precocity to its scion may be predetermined from the appearance or constitution of the young seedling. In the meantime there is no alternative but to subject the seedlings to the more protracted trials in the field.

Obviously, if any number of new rootstocks are to be tested and the unit of trees worked upon any one rootstock is to be sufficient to satisfy the requirements of adequate statistical analysis it is quite impossible to grow them as bush trees at 15 ft. apart as is being done with the sixteen varieties of so-called Paradise Apple Rootstocks being investigated at this Station. Some modification had to be devised which, if it did not give so comprehensive a picture over so long a period of the potentialities of the rootstocks under review, would at least provide a preliminary indication which might serve as a basis for further selection and subsequent more extended trial. As a possible satisfactory modification the system of " nursery trials " was devised. The rootstocks are planted out in rows 5 ft. apart, the stocks being approximately 1 ft. 6 ins. apart in the rows. The stocks are budded and the resulting trees left to grow *in situ* being treated, with certain modifications, as cordons. In this way some 5,800 trees can be grown to the acre.

During the Summer of 1930, three selections from a family of Northern Spy × Malling No. II and ten selections from a family of Malling No. VIII × Malling No. IX, multiplied in quantity and planted out in this way, were worked with Lane's Prince Albert. The trees were not pruned at the end of their first complete year's growth but subsequently all lateral growths of more than 1 ft. in length were shortened to four good buds from the base, laterals of less than this length and the leader being left unshortened. The pruning had perforce to be delayed until comparatively late in the Spring as a count of the blossoms upon the entire tree was required. The length of new wood made annually, the diameter of the stem at 3 ins. above the union, the number and character of the blossom trusses and the number and weight of the fruit was recorded. These data are summarized in the Table. In addition observations of a more general character were made from time to time.

Considerable caution must be exercised in drawing deductions from the figures given in the Table. The trial, which was the first of its kind to be laid down here, has many obvious shortcomings. For one thing, the trees were planted across the field without any attempt at randomization thus allowing full scope for the interplay of variation due to soil differences. Unfortunately too, the trial is very inadequately controlled. Forty-three stocks of Malling No. IX were worked at the same time as the seedling stocks. These enable a comparison to be made between the seedlings and the most dwarfing and precocious member of the Malling series. But no control trees are available which will enable one to compare the behaviour of trees upon the seedling stocks with that of those upon a typical vigorous and slow cropping member of the series. In spite of these limitations, however, a number of interesting facts have emerged from the trial and it has been possible in the light of the experience gained to evolve a technique which cannot fail to prove invaluable in dealing with subsequent similar trials.

As may be seen from the Table, the range of vigour as expressed by wood growth, in the selections from the family VIII × IX was wide. Thus trees on the most vigorous member of the series produced, on the average, well over three times as much wood, both at two and three years old, as those on the weakest member of the series, which also produced, at three years old, 140 cms. less wood, on the average, than the trees on Malling No. IX. The trees on the three immune selections from the family Northern Spy × No. II did not show any very wide variation in the wood growth produced. It is doubtful whether the differences at three years old are significant. While they were

		Average Wood Growth and Diameter of Stem.							
		At one year old.		At two years old.			At three years old.		
	Number of Trees.	Wood Growth. cm.	Diameter of stem. cm.	Wood Growth. cm.	Diameter of stem. cm.	Number of laterals.	Wood Growth. cm.	Diameter of stem. cm.	Number of laterals.
Spy × II									
789	28	104·3	0·94	539·0	2·04	14·4	1261·4	2·72	28·3
778	15	106·1	0·99	588·2	2·10	17·8	1281·4	2·85	32·1
793	47	109·4	1·00	607·2	2·00	17·8	1192·4	2·66	28·3
VIII × IX									
109	19	97·0	0·90	213·0	1·66	10·0	403·2	1·97	19·3
29	18	101·6	0·83	230·3	1·54	11·4	583·7	1·88	22·2
108	28	108·9	0·99	305·9	1·69	14·3	582·2	2·06	23·1
93	27	97·3	0·95	310·9	1·72	14·8	555·0	2·14	22·0
22	22	105·2	0·99	342·2	1·84	17·2	663·0	2·24	25·3
9	15	113·1	0·96	394·6	1·81	16·2	707·1	2·18	23·1
45	35	111·9	1·04	516·1	1·96	23·0	983·7	2·47	30·5
112	17	114·2	1·02	568·3	2·00	19·9	1205·2	2·53	33·3
89	17	117·6	1·04	645·5	2·13	22·3	1368·7	2·77	46·2
125	20	113·3	1·03	680·1	2·11	22·3	1415·6	2·81	41·8
IX	43	99·4	0·90	233·5	1·62	10·6	542·8	2·00	21·2

Average Number of Blossom Trusses.								Average Number and Weight of Fruits.					
At two years old.				At three years old.				At two years old.			At three years old.		
Terminal	Axillary.	Spur.	Total.	Terminal	Axillary.	Spur.	Total.	Number	Weight. ozs.	Weight per fruit.	Number.	Weight. ozs.	Weight per fruit.
0	0	0	0	0·4	1·0	9·0	10·4	0	0	0	3·5	20·1	5·6
0	0	0·1	0·1	0·3	2·8	16·2	19·3	0	0	0	6·0	25·3	4·2
0	0	0·1	0·1	0·5	1·0	10·5	12·0	0	0	0	2·4	13·0	5·3
0	2·1	0·1	2·2	1·1	18·1	40·5	59·7	0	0	0	10·5	52·2	4·9
0	1·3	0·5	1·8	1·8	14·2	37·2	53·2	0·05	0·3	6·0	5·1	28·6	5·6
0	0·4	0·4	0·8	2·4	21·8	42·1	66·3	0·1	0·5	5·0	9·0	46·3	5·1
0	0·1	0·9	1·0	2·4	26·5	44·8	73·7	0	0	0	8·8	48·2	5·4
0·05	1·8	0·9	2·7	2·4	20·5	44·7	67·6	0·1	0·7	7·0	5·1	30·9	6·1
0	0·4	0·2	0·6	2·4	12·2	34·4	49·0	0·2	0·8	4·0	5·3	29·7	5·6
0	0	0·1	0·1	2·5	15·0	35·4	52·9	0	0	0	9·3	42·3	4·5
0	1·0	0·1	1·1	1·0	10·0	31·7	42·7	0·1	0·5	5·0	2·9	17·1	5·8
0	0	0·9	0·9	2·6	22·3	26·7	51·6	0	0	0	3·4	16·9	4·9
0	0	1·5	1·5	2·2	22·9	24·0	49·1	0	0	0	4·1	19·5	4·7
0·02	3·7	0·3	4·0	1·2	17·2	31·1	49·5	0·4	2·5	6·2	5·5	29·3	5·3

more vigorous than trees on the majority of the VIII × IX seedlings, trees on at least two members of the latter family were the more vigorous, on the average, at two and three years old. The average diameter of the stems of the trees in the different families corresponds very broadly with the figures for the average wood growth. Certain discrepancies occur, however, which make it clear that this measure alone would not have been sufficient correctly to express the relative vigour of the seedlings.

Details of the number and position of the blossom trusses upon the trees were recorded upon two occasions, when the trees were two and three years old. While it is interesting to notice that the trees were bearing considerable blossom as early as two years old it was not until the trees were three years old that outstanding differences in blossoming habit had become apparent. In comparing the trees on the selections from family VIII × IX, as a whole, with those on selections from family Spy × II they are seen to belong to two distinct classes with regard both to the quantity and character of the blossoms borne. Thus, the ninety trees upon the three selections from Spy × II bore, on the average, 13·9 blossom trusses per tree while the 218 trees upon the ten selections from VIII × IX bore, on the average, 56·9 blossom trusses per tree. The former families, as a whole, had a relatively higher proportion of spur blossom trusses and a lower proportion of axillary blossom trusses than the latter. It may be added that trees upon the three selections from Spy × II were notable in coming into blossom later than those on selections from the other family and of No. IX. In the family VIII × IX the greatest average number of blossom trusses were borne by trees on selection 93 which carried, on the average, nearly 70 per cent. more blossom trusses than were borne by the trees on Malling No. IX. Trees upon this selection produced almost exactly the same amount of wood growth as those on No. IX at three years old. Of the ten selections from this family, seven produced trees which bore more blossom, on the average, at three years old than No. IX. There is probably little significance in the quantity of blossoms borne between the trees on the three selections 778, 789 and 793, the first being possibly slightly more prolific than the remainder.

Fruits were borne by the trees on certain of these rootstocks at two years old. The quantity, however, was negligible. At three years old a considerable amount of fruit was produced. The average number and weight of these fruits are presented in the Table. An outstanding difference between the two families immediately becomes apparent. Thus, the ninety trees of the three selections of Spy × II with an average of 13·9 blossom trusses per tree produced an average of four fruits per tree or 3·5 blossom trusses per fruit; 218 trees of ten selections of VIII × IX, with an average of 56·9 blossom trusses per tree, bore 6·3 fruits per tree or nine blossom trusses per fruit. Trees on four of the selections from family VIII × IX and on one selection from family Spy × II had a greater average number of fruits per tree than the control trees on No. IX. These figures do not suggest that fruitfulness was related in any way with vigour.

These are the chief facts which have emerged from these three years close study of some 300 trees upon seedling rootstocks. While it would be premature to draw any deductions from such young material observed over so short a period, there are already some interesting indications. Thus, although they have so far varied widely in their vigour as expressed by wood growth and girth, trees on all the selections from family VIII × IX appear to be showing the early prolific blossoming habits of the parent varieties. These trees will be kept under close observation for several years to come.

The writer's best thanks are due to Mr. R. J. Garner for his indispensable co-operation from the propagation side and to Mr. F. H. Beard for much assistance with the recording.

Summary.

Records, taken during three years, of the vigour, as expressed by wood growth and diameter of stem, the extent and character of blossoming and the number and weight of fruits, on trees of Lane's Prince Albert on selected seedling rootstocks from two families: Malling No. VIII × Malling No. IX and Northern Spy × Malling No. II, planted as a "nursery trial" are summarized and discussed.

References.

(1) Le Pelley, R. "Studies on the Resistance of Apple to the Woolly Aphis." Journ. Pom. and Hort. Sci., 1927, 3, 209.

(2) Tydeman, H. M. "Breeding Experiments with 'Paradise' Apple Rootstocks." Journ. Pom. and Hort. Sci., 1933, 11, 214.

NEW VARIETIES OF ROOTSTOCK FOR PLUMS
A PRELIMINARY REPORT ON TRIALS WITH SEEDLINGS OF *PRUNUS DIVARICATA*

By H. M. TYDEMAN

THE classification and testing of varieties of plum rootstocks in commercial use in this country is being carried out at this Station (1, 2). The collection here contains varieties belonging to at least four species: *Prunus domestica, P. insititia, P. cerasifera* and *P. spinosa*. While these rootstocks have been proved to exercise a fairly wide range of influence over all the scion varieties worked on them many of them show marked incompatibility particularly with the plum variety Czar. Moreover the propagation of many of the established varieties of plum rootstocks by vegetative means is difficult and expensive. For this reason a search is being made for new varieties which will prove compatible with all varieties of plum, prove easy to multiply by vegetative means and give a wide range of influence over the scion variety. While the chief emphasis is naturally being laid upon breeding work among existing varieties deliberately undertaken at this Station under controlled conditions, where they become available rootstocks obtained from other sources are being tested.

In November, 1931, a batch of 150 seedlings comprising twenty-nine families of *Prunus divaricata*, collected from various parts of Armenia, North Caucasus, Black Sea Region, Eastern Georgia, etc. were sent to this Station from the John Innes Horticultural Institution, where they had been under study from the genetic and cytological points of view. The seedlings were planted out in a nursery row upon receipt and during the following Summer were subjected to a careful examination on their botanical characters. They resembled one another fairly closely in most of the characters studied. The following is a general description:

Fairly erect, moderately vigorous or vigorous in growth, numerous long lateral growths, wood greyish-brown, young shoots deep reddish-purple; glabrous and rather coarse textured; lenticels few, inconspicuous, circular, creamy-white; leaves smallish, elliptical to oval, long and narrow, tapering to base and apex; serrations small, rounded, surface smooth and shiny; dark green, many pale hairs or almost glabrous; pose in relation to stem, slightly curved over or almost drooping, leaf stalk short, deep red, stipules usually serrate, lanceolate.

Hedrick (3) says: "*Prunus divaricata* is now considered by some botanists to be a synonym of *Prunus cerasifera* and by others to be a botanical variety of the last named species. Ledebour, who named it, found it growing in the Trans-Caucasian region. It differs from the type only in having much divided, wide spreading and nearly prostrate branches. . . . A plum now growing in the Arnold Arboretum, raised from seed from Turkestan, presumably from wild stock, is identical with plants of *cerasifera* of European origin."

It was decided in the first instance to see how far these seedlings would prove compatible with the variety Czar, since, in general, rootstocks which prove compatible with this variety, show themselves compatible with most other varieties of plums.

The stocks were budded with Czar during the late Summer of 1932. In order to eliminate as far as possible the effects of bud failures due to manipulative faults, from one to three buds were inserted into each stock, the number varying according to the size of the stock. Owing to an oversight all these buds were allowed to grow unchecked. The result was that in some cases, two and three distinct maiden stems were growing upon one rootstock. The growth made by the trees was measured during the Winter of 1933. All the data so far available is summarized in the Table.

TABLE.

	No. of Seedlings.	No. of Buds inserted.	No. of Seedlings which failed to take the Bud.	No. of Buds alive 6/1/34.	Average length of Shoot per Bud. Cms.	Average length of Laterals per Shoot. Cms.	Average length of Growth per Seedling. Cms.
3/32508	3	8	0	5	221·2	245·8	778·3
369/33253	3	6	0	5	219·0	171·0	650·0
265/32972	3	6	0	5	214·2	336·8	918·3
273/18255	5	11	0	10	203·8	161·4	730·4
63/18794	4	6	1	5	202·8	251·4	567·7
144/33057	4	9	0	8	195·4	184·0	758·7
157/33381	8	18	1	9	191·0	366·8	640·0
77/32191	4	7	1	5	190·2	277·0	584·0
35/32484	5	12	0	12	190·0	111·2	722·8
221/18119	3	6	0	5	186·0	160·6	577·6
545/32502	7	15	1	8	185·5	142·4	374·7
247/18808	7	14	2	6	177·3	498·9	579·6
33/33472	4	9	0	7	177·1	233·7	719·0
350/33086	2	4	0	4	175·6	181·2	714·0
66/32698	4	9	0	9	173·0	65·5	536·7
109/33582	5	10	0	8	170·6	133·7	487·0
Black Damas C	17	17	2	15	170·5	473·3	587·6
243/32219	4	10	0	8	164·0	37·5	403·0
393/32240	4	9	0	7	159·7	70·0	402·0
E/205	7	15	0	13	159·4	158·3	590·1
350/32478	4	8	0	6	159·6	98·2	386·7
145/32111	4	8	0	8	156·0	65·5	443·0
202/17998	5	10	2	6	155·3	148·2	364·2
167/32410	6	15	0	12	155·0	74·5	459·0
57/32040	8	19	1	13	145·1	129·9	447·0
22/33558	6	13	0	11	142·6	147·0	531·0
2/33302	8	15	0	13	140·5*	204·5	560·8
214/32449	5	13	0	10	133·9	44·1	356·0
484/32303	7	14	0	14	129·6	66·1	391·4
36/32569	6	13	0	11	129·3	224·5	648·7
15/33315	6	13	1	11	91·6	43·7	248·2

* One shoot broke out at the time of measuring.

In considering the results presented in the Table it is interesting to notice that none of the families of seedlings under test proved completely incompatible with Czar and in only eight cases did all the buds fail upon any individual seedling, within a family. In family 2/33302 a case of incompatibility occurred common with certain combinations of plum rootstock and scion. One shoot upon a seedling, although apparently growing healthily, parted company with the rootstock while it was being measured. Considerable care must be exercised in interpreting the figures for the average length of shoot per bud given in the Table. Since several buds were inserted into most rootstocks and the shoots produced allowed to grow unchecked, the effects of competition must have

greatly modified the results. Nevertheless, since all the families were treated more or less similarly the figures probably represent the approximate order of relative vigour among the seedlings. As the figures show there was a wide range of variation in the length of the shoots. Thus the greatest average vigour was displayed by the members of family 3/32508, a family from Azerbaijan and the least by family 15/33315, from Dagestan. Actually the most vigorous family had shoots on the average approximately 2·5 times as long as those produced by the least vigorous family. As may be seen the lateral growths produced by the shoots from the seedlings varied within very wide limits.

The shoots on the seedlings are being reduced to one during the present season and the experiment is being continued.

The writer's thanks are due to Mr. M. B. Crane of the John Innes Horticultural Institution for supplying the rootstocks and to Mr. R. J. Garner for his collaboration from the practical side.

Summary.

This paper deals with a trial of Czar plums worked on seedlings of *Prunus divaricata*. The " take " of buds and the wood growth of the year old trees are presented and discussed.

References.

(1) Hatton, R. G. " Stocks for the Stone Fruits." Journ. Pom. and Hort. Sci., 1921, **2,** 1.

(2) Hatton, R. G., Amos, J. and Witt, A. W. " Plum Rootstocks : Their Varieties, Propagation and Influence upon Cultivated Varieties Worked Thereon." Journ. Pom. and Hort. Sci., 1928, **7,** 63.

(3) Hedrick, U. P. " The Plums of New York." New York Agric. Expt. Stn.

A METHOD OF CONVERTING UNPROFITABLE FRUIT TREES

By R. J. GARNER

It is well known amongst fruit growers who own established plantations and orchards that a proportion of the varieties contained therein are often either very poor financial propositions or are actually maintained at a loss. Even so it often happens that were the unprofitable varieties to be grubbed the profitable kinds would then fail to set a satisfactory crop, owing to lack of cross-pollination. Again, a number of trees which were planted from ten to twenty and more years ago are now, just when they are coming into possession of their maximum bearing surface, found to be very susceptible to injury by sprays which are essential for the well-being of adjacent profitable kinds. Often the injurious spray is applied and consequent loss of crop on the susceptibles is unavoidable. Cases in point are sulphur-shy varieties planted amongst those which are prone to attacks of scab. Similarly, from a manurial point of view, established plantations are quite frequently found to contain varieties which require differing manure ratios and one is correctly manured to the detriment of the other or a compromise results in unsatisfactory returns from both. In quite a few cases areas have been planted with one variety only, which, though a suitable kind from many points of view, has never yet cropped, owing to lack of suitable cross-pollination.

Should any or all of the foregoing conditions obtain it is at once obviously desirable to attempt to convert the unprofitable into profitable trees. This, at least in England, has in the past been done by top-grafting in various ways practically all of which involve severe deheading of parts, or even of the whole of the tree at one time, and consequent loss of valuable framework branches which may have required many years in which to attain size. Where trees are in a good state of health and where the grafting operation is carried out with necessary care and precision excellent results in regard to " take " and growth have occurred. However, even in the most successful cases, it has often required a five year or even longer period before the tree comes into profitable bearing. This time factor is a matter for serious consideration.

Much the same difficulties as are experienced in England are experienced in other parts of the world, especially where it has become imperative that only a certain few varieties should be grown for shipment to overseas markets. In Australia and Tasmania, some years ago English varieties were grown in a first attempt to supply the overseas market. These in almost all cases have now been found to be quite useless for the purpose, and a method involving the retention of the tree-framework, with the complete replacement of the fruiting laterals with a chosen variety, has been used with very great success (1, 2, 3, 4).

It was found that when old-established apple trees were prepared for normal top-grafting by severe deheading they often became infected with papery-bark canker (*Polystictus versicolor*) which, it is reported, rapidly killed the trees. It appears that the large open wounds occasioned by the entire removal of branches opened the way to attack by the fungus and conversely, when small wounds were made, which incidentally were more quickly healed, the incidence of disease was not nearly so frequent.

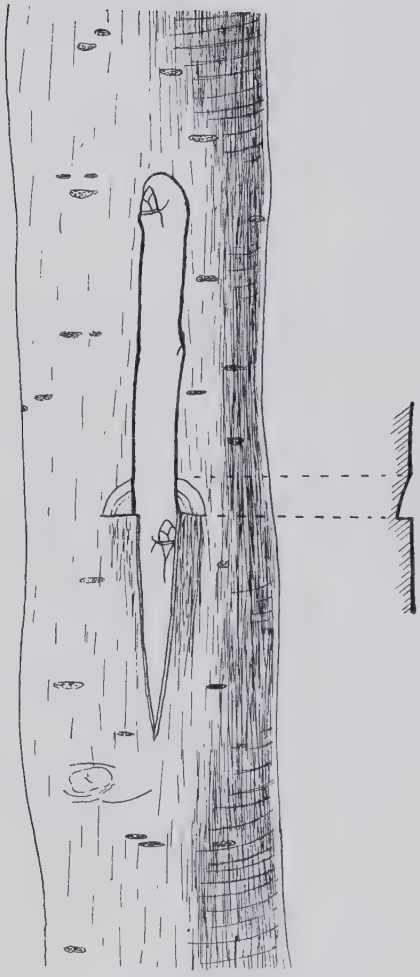


Diagram 1.

Primarily to avoid trouble due to papery-bark canker, growers hard-pruned their trees, retaining the necessary framework branches and placed numerous scions on every branch wherever it was thought desirable to have fruiting spurs or lateral branches. Medium sized bush trees were found to require upwards of 200 grafts and larger trees are reported to have received as many as from 500 to 1,000 grafts per tree (4). Such trees were planted twenty-nine years previously.

Trials at East Malling.

(1) Apples.

Early in April, 1933, eight twelve-year-old trees of the apple variety Stirling Castle worked upon rootstock No. XVI, which were originally planted between Cox's Orange Pippin at the Research Station for pollination purposes, were selected to test, under English conditions, the method of framework or " porcupine " grafting, as it has since been termed by its exponents overseas.

Firstly it was found unnecessary to remove any of the main branches owing to the excellent shape of the trees due to previous pruning. All the small lateral branches and fruit spurs were cut to within approximately 2 ins. of their origin. All these stubs were then grafted with the variety Worcester Pearmain by use of the normal whip-and-tongue graft which was afterwards tied and waxed. The scions were placed as close as possible to the framework branch so that there remained a minimum length of Stirling Castle wood from which sucker shoots might arise. In addition to the grafting of the laterals the tip of each branch received a graft and, wherever the framework was found to be devoid of laterals, grafts were inserted actually into these main branches. These last were inserted in two ways. In the one method a T shaped cut was made down to the wood with the stem of the T 1 to 2 ins. long and parallel with the direction of the limb to be grafted. The scion was then cut with a single long slanting cut, as used in whip grafting, and inserted under the lips of the bark which were raised as in the process of budding. It was found that the removal of a wedge shaped portion of the bark immediately above the T cut, as in Diagram 1, facilitated the close connection between scion and

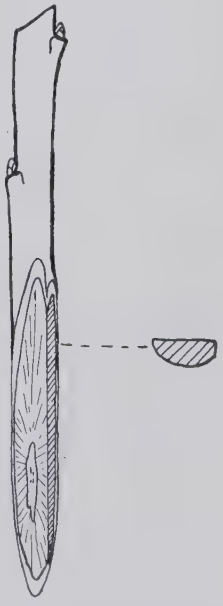


Diagram 2.

branch. The second method was carried out similarly and only differed in an inverted L shaped cut being used with a cut of right-angular section on the scion as in Diagram 2. In both limb-grafting methods the grafts were tied with raffia which was passed around the grafted branch.

Where raffia was used for tying the small grafted stubs it was found that severe constriction was likely to occur and it was necessary to remove the raffia and re-tie until the graft had become established. The tying and necessary re-tying was found to be the most irksome operation involved and because of this a few grafts were put on by a method which is described as " stub-grafting " ; previously used with success in the nursery row. No tying is required and the operation is as follows. The scion is prepared with its basal end in the form of a wedge with one slanting cut about $\frac{1}{2}$ in. and

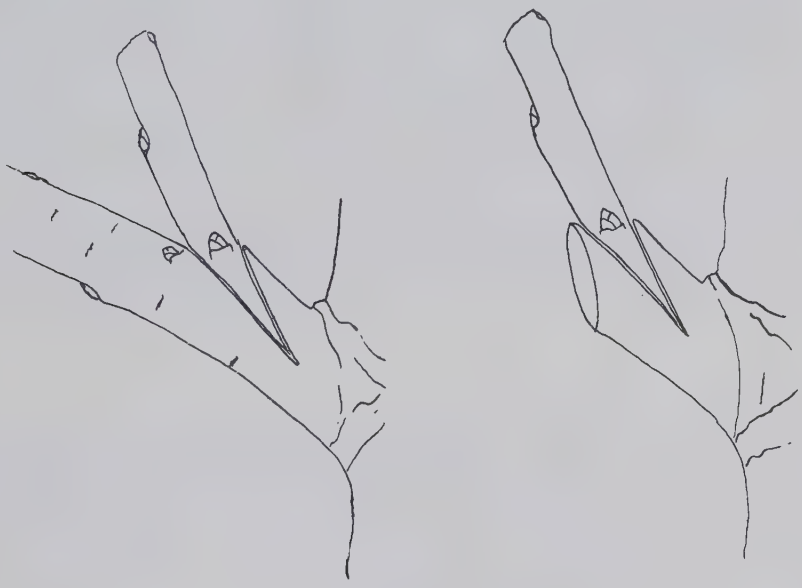


Diagram 3.

the other about 1 in. long. The lateral branch to be grafted then receives a cut which commences $\frac{1}{2}$ in. from the main branch and extends down to the base and almost to the centre of the lateral shoot. The cut is opened by bending the lateral and the prepared scion is inserted, after which the shoot is released and cut off immediately above the insertion of the scion. If the operation is successful the scion will be held very firmly and no tying will be required. All cut surfaces should be waxed over as in other methods. The method is illustrated in Diagram 3.

To avoid the use of tying-material on the main stem certain growers in Tasmania have inserted grafts in inverted L shaped cuts, as described above, and, in place of any other mode of fixing, have used a $\frac{5}{8}$ in. brad driven through the scion into the main branch. It is claimed that, after waxing, no further attention is required. This last method has not so far been used in the trials at the Research Station but it is hoped to test this under our conditions this season. It follows then that the complete tree may be grafted without recourse to the use of any tying-material whatsoever.

Number of Grafts Required.

The eight twelve-year-old trees of Stirling Castle used in the trials varied in height of branches from 3·0 to 3·7 and in spread from 1·8 to 2·6 metres with a mean height and spread of 3·3 and 2·1 metres respectively.

The number of grafts used on each of the trees varied from 121 to 266, depending upon the nature of the branch system, this being an average of 177 per tree.

With as few as eight trees it was difficult to arrive at any exact costings, but it is estimated that two operators working together will complete approximately fifty grafts per hour. This figure does not include time spent in preparation of the tree or the numerous other tasks necessarily involved prior to any grafting operation. Moderate sized bush trees, such as those described above, requiring approximately 200 grafts, may cost anything up to 7s. 6d. per tree for the complete re-furnishing. Under Tasmanian conditions " porcupined " trees have borne from five to twelve cases per tree eighteen months after grafting and, considering the early results obtained, it has proved a very profitable proceeding.

(2) Plums.

In addition to the trials with apples at East Malling two eight-year-old trees of Laxton's Utility plum have been successfully framework grafted. In this case no grafts were placed directly on the main branches but all on to lateral branches approximately $\frac{1}{2}$ to 1 in. in diameter. A hundred grafts were found to be sufficient to re-furnish a tree having a spread of some 12 ft. and it would appear that less grafts are required on plum than on apple trees owing to the mode of cropping and the almost complete absence of any pruning akin to that practised with apples.

The application of frameworking methods to stone fruits may prevent the incidence of such diseases as Silver Leaf (*Stereum purpureum*) by avoidance of the large open wounds necessarily involved by the use of top-grafting methods accompanied by severe deheading of the tree. Losses due to the effect of bacterial canker in plums and cherries of late years have drawn attention to the possibility of using the method of re-furnishing, herein described, to limit the spread of the disease within the tree. Wormald has recorded (5) that certain varieties of plum are definitely more resistant than others to the attacks of bacterial canker and suggests that it would probably be advantageous to have trees with the stem and main branches composed of such varieties. Reimer (6) describes the successful use of similar methods in combating the serious fire-blight disease of pears.

After Care.

Once the tree is completely furnished with grafts nothing further is necessary until growth commences when any growths which arise, other than from the scions, should be rubbed out whilst still soft and green. In the trials at East Malling a very little attention sufficed to keep down these growths and it is anticipated that in future years attention at the time of the annual pruning will be adequate to keep under any sucker shoots from the stock variety.

Where raffia or similar material has been used for tying the grafts on the lateral shoots it will probably be necessary to remove this to avoid constriction as growth proceeds. This attention will obviously not be required in cases where the " stub-graft " has been used as previously described.

FIG. 1.
Stirling Castle apple top-grafted with Worcester Pearmain.
Compare with Fig. 2.
Photographed four months after grafting.

FIG. 2.
Stirling Castle apple re-furnished with Worcester Pearmain
Compare with Fig. 1. All the young growth is Worcester Pearmain.
Photographed four months after grafting

FIG. 3.
Stirling Castle apple re-furnished with Worcester Pearmain.
All young growth is Worcester Pearmain.
Photograph taken four months after grafting.

Summary.

Instances are given of the need of conversion of unprofitable into profitable trees. A method used by Dominion fruit growers is described and details are given of trials in progress on similar lines at East Malling. A variation in grafting-technique is described and figures are given whereby the cost of the operation may be estimated.

References.

(1) Ward, J. M. "Budding, Grafting and Inarching of Fruit Trees." Bulletin No. 63 (New Series), Dept. of Agric., Victoria, Australia.

(2) Thomas, P. H. "Converting the Unprofitable Fruit Tree." Tasmanian Journal of Agriculture, 1/8/30.

(3) ——— "The Reworking of Fruit Trees." Bulletin 3 (New Series), Dept. of Agric., Tasmania.

(4) Anon. "Top-grafting Fruit Trees." Article in Tasmanian Mercury, 1/3/32.

(5) Wormald, H. "Bacterial Diseases of Stone Fruit Trees in Britain. V. Some field observations and experiments on Plum Bacterial Canker." E. Malling Res. Sta. Ann. Rep., 1933.

(6) Reimer, F. C. "Blight Resistance in Pears and Characteristics of Pear Species and Stocks." Oregon Agric. College Expt. Station Bull. 214.

PLUM ROOTSTOCKS—A NOTE ON SOME ROOT-SYSTEMS

By E. G. ING

In a paper on stocks for stone fruits (1) the root-systems of some unworked plum stocks are described. After several years an opportunity occurred for observations to be made on the nature of the root-systems of these stocks, worked some years ago with various plum scions. These were planted as two-year-old trees in 1921 and were grubbed in December, 1932.

Root-Systems of Unworked Stocks.

The following extracts from (1) describing the root-systems of unworked stocks are given for purposes of comparison.

Stocks Raised Vegetatively.

Brussel.

"A compact root-system well balanced between medium coarse laterals and abundance of fibre. It is noticeably free in sending out new adventitious roots."

Pershore.

"The root-system has coarse laterals more sparsely fibred than Brussel."

Brompton.

"The developed roots show very stout laterals with only a moderate amount of fibre, with a tendency to grow somewhat horizontally."

Common Mussel.

"The mature root-system has many strong spreading laterals, well fibred and apparently deeply anchored."

Shiny-leaved Mussel.

"The mature root-system differs somewhat from that of the Common Mussel, appearing to be less strong and spreading."

Common Plum.

"The mature roots show a well-balanced mixture between coarse laterals and fibre."

Stocks Raised from Seed.

Myrobolans.

"They develop very vigorous root-systems."

Root-Systems of Worked Stocks.

The root-system of the trees referred to at the beginning of this note were examined at grubbing. The following is a summary of notes made.

Brussels.

Root-system medium to small, generally horizontal, fair number of longish to large roots, few to several medium and small roots. Distinguished by the presence of a considerable quantity of small fleshy roots growing at right angles to the main roots, by the considerable amount of fibre and the brittle nature of the larger roots. The larger roots often broke off at 1 to 2 ft. from the base of the trunk.

The root-systems worked with Denniston's Gage were larger than those with Victoria as the scion variety.

Pershore.

Root-system small to large, larger when worked with Denniston's Gage and Belle de Louvain than with Czar. A few long to very long fairly large roots, gradually tapering and fairly straight. Number of medium to small roots variable but generally fewer than Brompton. Little fibre. Branching of roots sparse, acute and towards the extremities of the main roots.

Brompton.

Medium to large root-systems. Trees of Denniston's Gage had large root-systems—those of Victoria and Czar were small. Total number of roots more than Pershore, more medium sized roots and more fibre. Roots not so regular, but generally more rigid than those of Pershore. Occasionally some roots were to be found growing straight down into the soil.

Common Mussel.

Root-system small to medium. Roots medium to longish, mainly horizontal, several small roots, and fair amount of fibre. Worked with Victoria rather brittle.

Shiny Mussel.

Similar to Common Mussel with the exception of possessing more medium sized roots.

Common Plum.

Root-system fairly large, roots largish to large, mainly horizontal, occasionally irregular—changing direction at short intervals, fair to considerable amount of fibre.

Myrobolan (Seedlings).

Very firmly rooted, generally the largest of root-systems, consisting of three to four very large, long coarse roots, together with a few fairly large ones, few to several medium sized and a few small ones. Very little fibre. Roots appear bare in comparison with other rootstocks. The large roots are generally of greater diameter near the trunk than those of any other stocks and abruptly decrease in diameter. They branch rather freely, such branching commencing fairly close to the trunk. Medium and small roots frequently observed to be growing straight down. Although, as previously noted, the root-systems were generally the largest met with, rather more variation was observed than with vegetatively raised stocks. Denniston's Gage trees had larger roots than Czars.

St. Julien (Seedlings).

Considerable variation in the size of the root-systems was found. The variation was generally from medium to large size, although occasionally some rather small ones were found. The direction of the roots varied from being entirely horizontal to others with some horizontal roots and the rest growing straight down into the soil. Medium

and small roots varied in number, as also did the amount of fibre. The best fibred stocks had a fair amount. Some of the larger ones approached the Myrobolans in character, but differed in having rather more fibre, whilst others somewhat resembled Mussels and small Pershores. The difference in size between sets of roots worked with Denniston's Gage and Czar was not appreciable.

Black Damas (*Seedlings*).

Variable in size, generally small to medium, occasionally fairly large, mainly horizontal. Fair number of longish to large roots, a variable number of medium and small ones. Considerable variation in amount of fibre—very little to fair.

From these observations three points of interest arise.

1. That the roots of different rootstocks after growing several years stem-worked with several scion varieties still differ in the qualitative nature of the root-system and that vegetatively propagated stocks of one kind, worked with different scion varieties do not differ appreciably in botanical character, although the size may be influenced by the nature of the scion worked thereon.

2. That the roots of trees worked on the various stocks still retain, after growing several years, most of the characteristics of the young unworked stocks.

3. Seedling rootstocks of any one of the three kinds studied, whilst bearing some general resemblance, varied much more in size of the root-system, the size and number of individual roots and in the amount of fibre than did vegetatively propagated stocks. This variation was particularly noticeable with the St. Juliens.

Roothold.

The following notes on firmness of roothold are based on observations made at the time of grubbing.

Myrobolan. Firm to very firm.
St. Julien. Moderately firm to very firm—majority firm.
Pershore. Moderately firm to very firm—majority firm.
Common Mussel. Firm.
Brompton. Majority moderately firm to firm.
Common Plum. Moderately firm to firm.
Brussels. Poor to firm, majority poor to only moderately firm.
Shiny Mussel. Poor to firm.
Black Damas. Poor.

SUMMARY.

Brief notes are given on the nature of the root-systems of several plum stocks.

REFERENCES.

(1) HATTON, R. G. "Stocks for the Stone Fruits." Journ. Pom. and Hort. Sci., Vol. II, No. 4, Sept., 1921.

(2) HATTON, R. G., AMOS, J. and WITT, A. W. "Plum Rootstocks: Their varieties, propagation, and influence upon cultivated varieties worked thereon." Journ. Pom. and Hort. Sci., Vol. VII, Nos. 1 and 2, July, 1928.

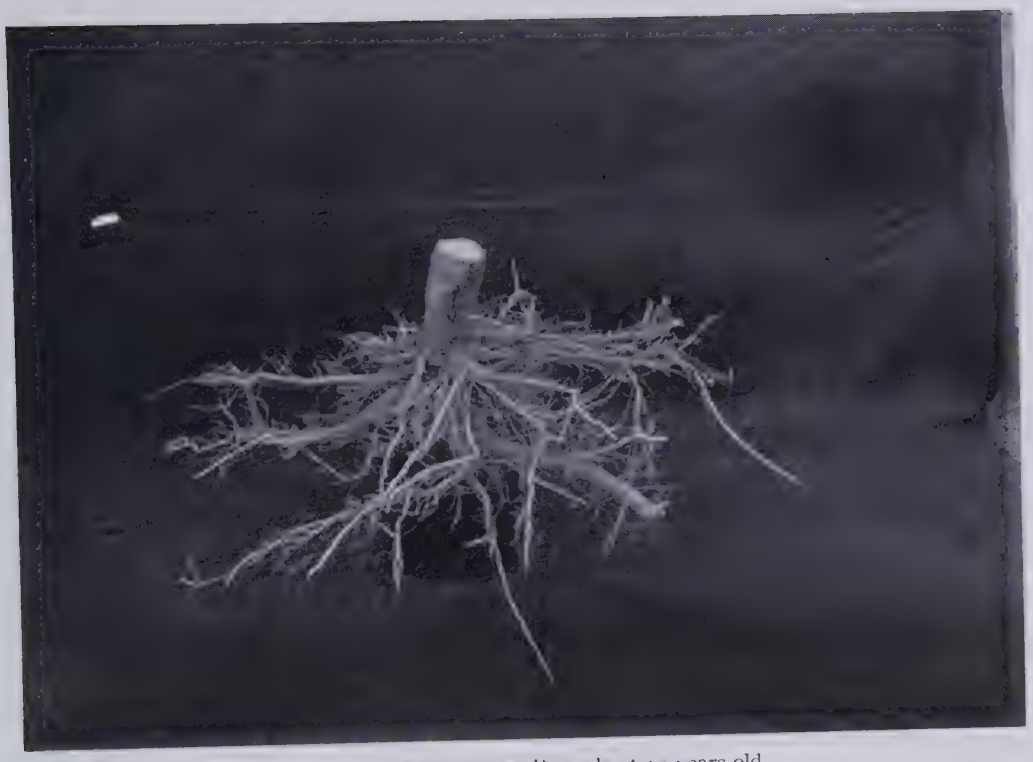


FIG. 1. Root-system of Brussels at 10 years old.

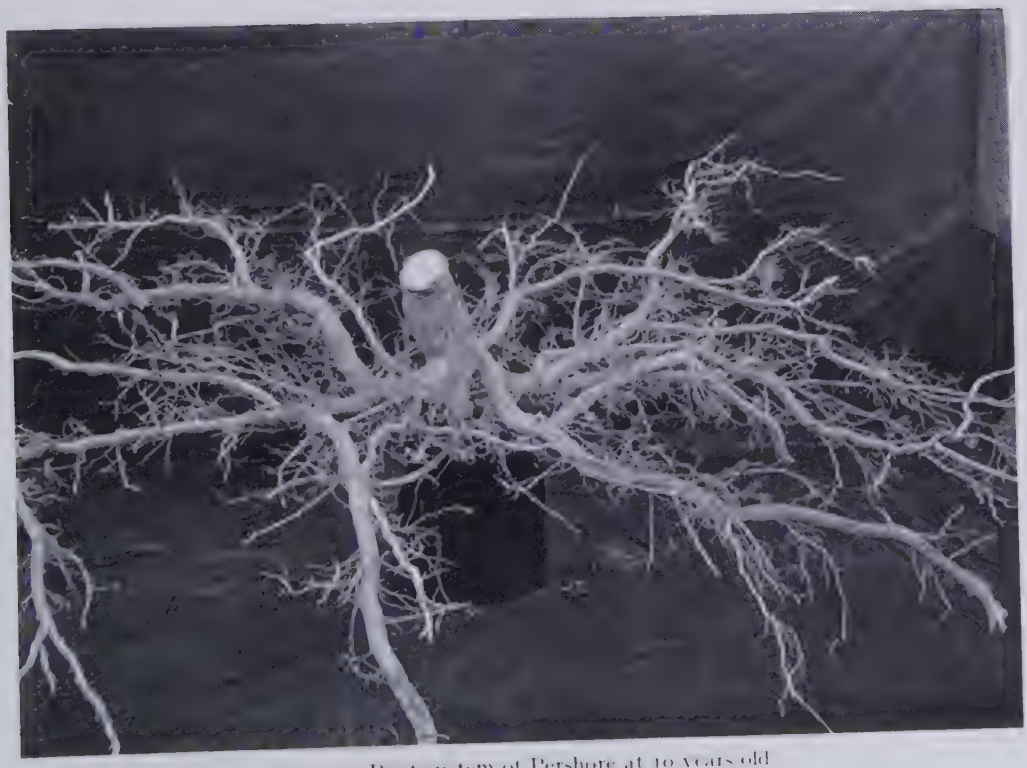


FIG. 2. Root system of Pershore at 10 years old

FIG. 3. Root-system of Brompton at 10 years old.

FIG. 4. Root-system of Common Mussel at 10 years old.

Fig. 5. Root-system of Common Plum at 10 years old.

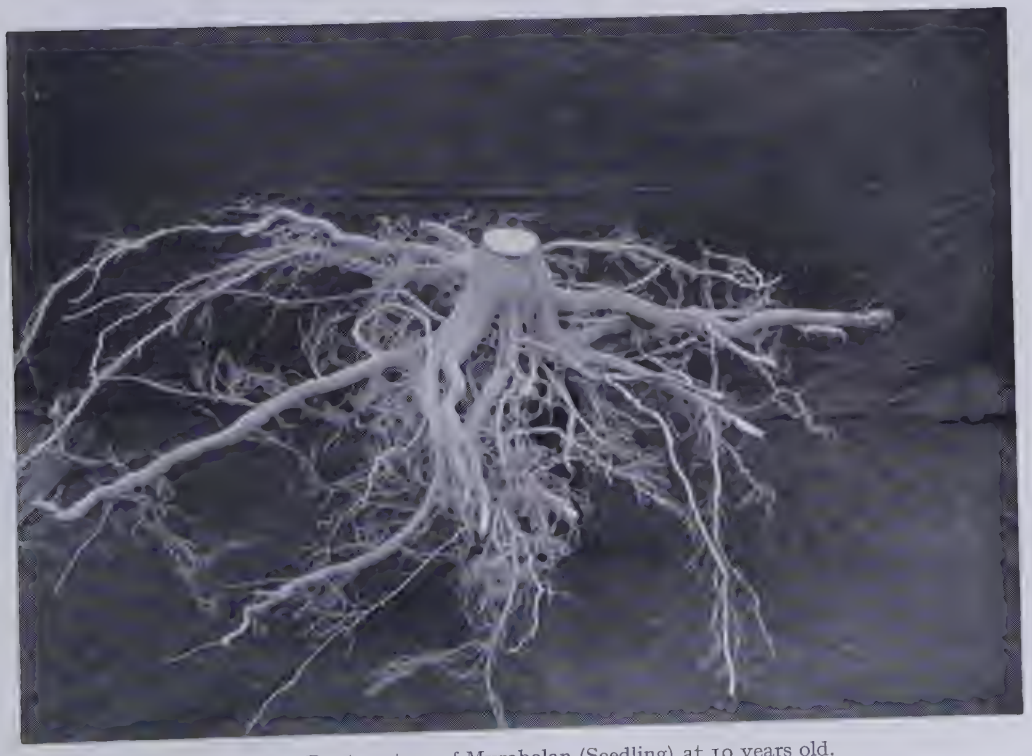


Fig. 6. Root-system of Myrobolan (Seedling) at 10 years old.

WEATHER CONDITIONS DURING 1933

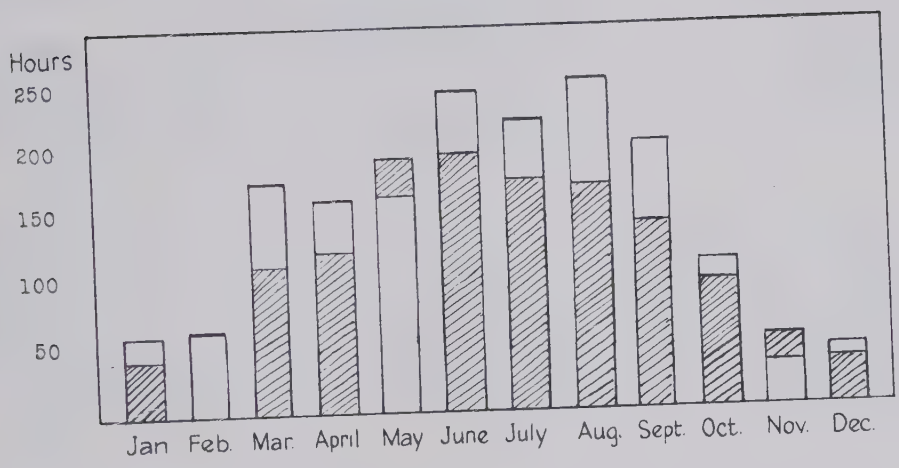
By H. C. CHAPELOW and H. M. TYDEMAN

In many respects the year 1933 has been an exceptional one. Sunshine was extremely plentiful, the year's total of 1,767 hours was 311½ hours in excess of the eighteen years' average here. During all the months except February, May and November sunshine was in excess of the normal while during March it was actually 57 per cent. above the average. Rainfall, on the other hand was rather scanty, the year's total of 21·34 ins. being slightly more than 4 ins. in defect of the eighteen years' average for this neighbourhood. Nevertheless, although small, the year's total was larger than those recorded in 1920 and 1921. An exceptional feature of the present year, however, has been the very dry conditions experienced during the last three months of the year. The total rainfall for October, November and December only amounted to 3·53 ins., the smallest total for these three months ever recorded at this Station. Towards the end of the year the water shortage was becoming serious in many parts of the country. With regard to temperatures, January, November and December were below the average, while March, April, June, July, August and September were above the average. A series of severe frosts in late April caused considerable damage to the blossom, chiefly that of strawberries, cherries and plums. Very high day temperatures were recorded during July and August. A sequence of thunderstorms occurred during June and July, several of these accompanied by severe hail which did considerable damage to the fruit crops. An exceptionally severe thunderstorm occurred on 21st July when 1·35 ins. of rain fell in a comparatively short time.

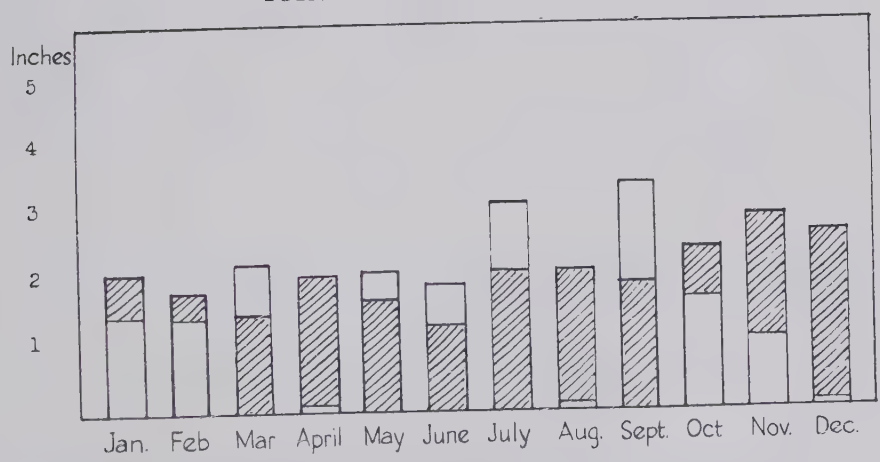
SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1933.

	Temperature in Screen.					No. of Ground Frosts.	Rainfall.			Sunshine.			Soil Temperatures.		
	Mean Maximum.	Mean Minimum.	Highest.	Lowest.	Mean.		Total in inches.	18 years' average.	Heaviest fall in a day.	Total hours.	18 years' average.	Average per day.	4 inches.	8 inches.	2 feet.
January ..	41·4	30·8	53	19	36·1	24	1·52	2·22	0·40	59·8	48·2	1·93	36·8	37·8	40·9
February ..	45·5	34·3	55	21	39·9	16	1·46	1·82	0·40	68·5	68·7	2·45	37·5	38·3	39·8
March ..	54·5	35·9	64	27	45·2	20	2·33	1·48	0·50	182·2	118·0	5·88	41·1	41·5	42·4
April ..	58·8	38·2	72	27	48·5	12	0·85	2·13	0·31	164·8	127·1	5·49	47·5	47·1	47·8
May ..	63·5	43·3	78	33	53·4	2	2·21	1·77	0·61	164·8	195·0	5·32	54·9	54·0	53·6
June ..	69·6	46·9	83	39	58·3	0	2·01	1·37	0·56	247·2	200·4	8·24	60·6	59·8	60·5
July ..	73·8	57·5	88	45	65·7	0	3·18	2·24	1·35	226·1	185·2	7·29	65·0	65·1	64·2
August ..	75·4	52·4	88	43	63·9	0	0·69	2·20	0·18	256·6	181·3	8·28	65·3	65·3	66·7
September ..	68·6	48·8	79	36	58·7	0	3·56	2·05	1·01	205·1	147·0	6·84	60·4	60·7	62·7
October ..	58·0	43·5	67	29	50·7	10	1·73	2·52	0·47	113·4	100·5	3·66	51·4	52·2	55·7
November ..	46·9	35·2	57	27	41·0	16	1·14	2·90	0·23	33·9	56·0	1·13	41·9	43·1	46·4
December ..	34·9	29·4	43	21	32·1	28	0·66	2·68	0·15	45·2	38·8	1·46	33·5	34·6	38·0

TOTAL SUNSHINE IN HOURS.



TOTAL RAINFALL IN INCHES.



Diagrams showing Total Sunshine and Rainfall during 1933 as compared with 18 years' average. Shaded portion 18 years' average.

PHYSIOLOGY

FURTHER OBSERVATIONS ON THE PARTS PLAYED BY ROOT AND STEM IN STOCK INFLUENCE

By R. C. KNIGHT

A PROGRESS report was published in 1927 (3) on the first three years' results obtained from experiments designed to give information regarding the relative importance of the stem piece and the root system of the stock in the influence conveyed to the scion. The trees concerned were eventually grown on to the age of six years, detailed records being taken annually, when they were lifted and subjected to morphological analysis. The results obtained in the later years were in substantial agreement with those previously obtained and published and have been referred to by Hatton (2) in a discussion on the theory of stock influence.

In view of the further work which has appeared on the question of stock influence (1, 2, 4) and the respective parts played by root and stem, it is considered appropriate to publish the details of the later records obtained on the trees in question. A full description of the technique has already appeared (3) and it is proposed now merely to extend the table shown in the earlier publication so as to include the later results.

The material consisted of four series comprising the four possible combinations of two root systems (one dwarfing and one vigorous) and two intermediates (of the same varieties as the root systems) with the same scion. The *a priori* argument was that if the intermediate piece of stem was the prime factor in determining scion performance, then two trees with similar intermediates but with different root systems would exhibit similar scion characters whilst on the other hand differences in the scion would indicate that root system was more important than stem.

Table I and Fig. 1 show the results for the six year period.

TABLE I.

TOTAL SHOOT GROWTH AND BLOOM BUDS PER TREE OF LANE'S PRINCE ALBERT.

Double Grafted.

Series Intermediate Stock	A I I		B IX I		C I IX		D IX IX	
Year.	Shoot Growth.	Bloom Buds.	S.G.	B.B.	S.G.	B.B.	S.G.	B.B.
	cm.		cm.		cm.		cm.	
Maiden	95	0	100	0·5	60	2·2	51	2·2
2	183	0·7	157	3·2	112	5·2	93	5·7
3	367	6·5	271	16·2	211	25·0	174	26·3
4	904	43·3	499	51·7	439	71·5	415	77·6
5	1,744	113·5	939	90·7	753	151·0	669	157·6
6	2,472	146·5	1,177	150·5	1,079	186·0	921	168·9

The figures given for each year are the totals up to and including that year and show that comparing series A, B and C the substitution of a dwarfing for a vigorous rootstock produces a much greater effect on both shoot growth and blossom production than does the replacement of a vigorous by a dwarfing intermediate. At the other extreme, series D, C and B, the change of rootstock has a greater effect than the change of intermediate

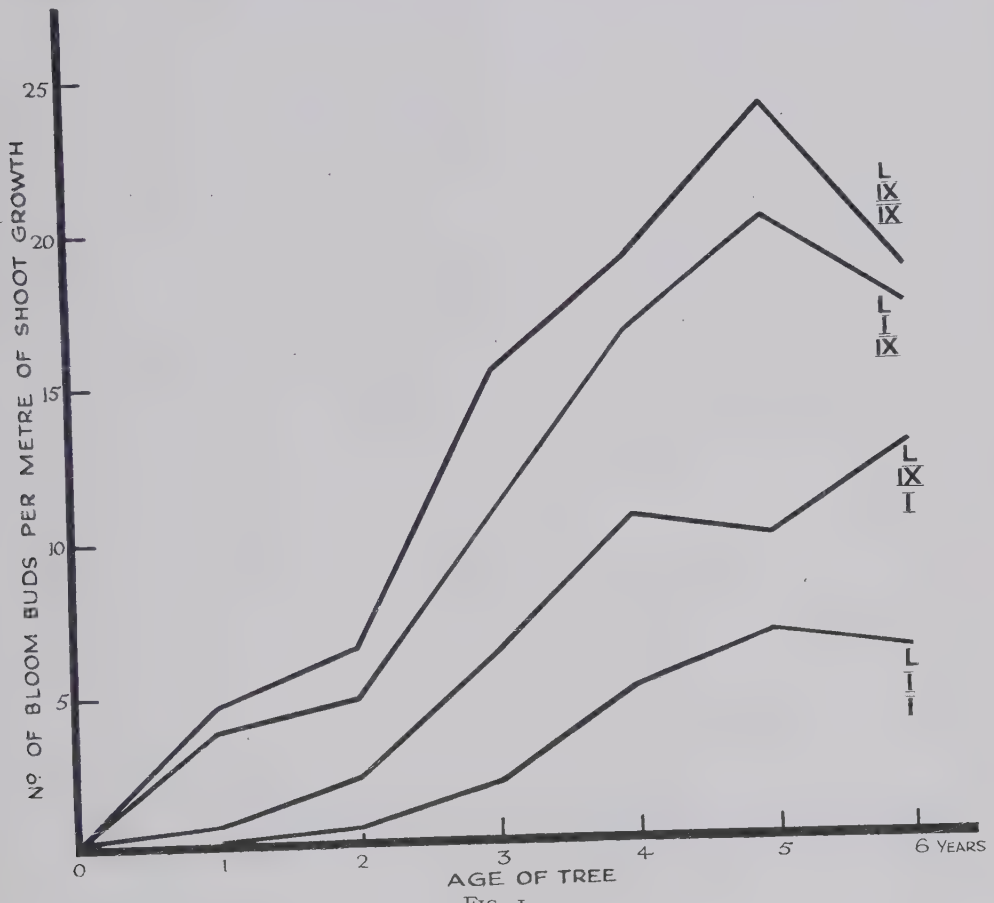


FIG. 1.

Influence of Root System and of Intermediate Stem on Blossom Bud/Shoot Growth Ratio of Lane's Prince Albert.

stem piece. If the figures for each year are considered separately instead of the accumulated totals, then in spite of the variability due to season, to the small numbers used and to the tendency towards alternate bearing, the same conclusion is unavoidable since only five values of the whole forty-eight fall outside the general sequence. For example in the sixth year and in that year only the shoot growth of series B was less than that of series D.

After six years' growth the trees were lifted and total stem weight per tree was found to be as follows:

Series	A	B	C	D
	1660	809	674	658

These figures confirmed the conclusion which followed from annual measurements of shoot growth, the ratios between the four series being

100 : 49 : 41 : 40 for final stem weight and
100 : 48 : 44 : 37 for total length of new shoots.

These supplementary figures thus provide additional evidence in support of the conclusion tentatively reached from three years' results that the part played by the stock stem in influencing the scion is subsidiary to that played by the root system.

It must be realized that these experiments take no account of any influence which might accrue from the union itself, as distinct from both stem and root of the stock. In seeking the causes of stock influence the first impulse is to consider the possibility of nutritional differences being due to selective absorption by the roots, and selective translocation by the stem. It is not impossible, however, that the union between stock and scion may also play a part by a process of the nature of " selective filtration ", although at present there is no evidence of the existence of this factor.

In the present experiments the constitution of the trees of series A and B, for instance, involves incidentally a difference in unions. Series A possess a Lane's/I and I/I union, whilst series B have a Lane's/IX and a IX/I union. Should anatomical or growth-period differences involve functional differences between such unions, tree performance in the two series may be affected by this factor, which, although at the moment no more than a possibility, should not be neglected.

Further larger series of trees comprising different combinations of stock, intermediate and scion have been under observation for some years.

Summary.

Records of trees up to six years old have confirmed the conclusion indicated by three years' records that the root system is more important than the stock stem in determining scion performance.

References.

(1) Amos, J., Hatton, R. G., Hoblyn, T. N., and Knight, R. C. " The Effect of Scion on Root. I—Stem Worked Apples." Journ. Pom. and Hort. Sci., 1930, **8**, 248-58.

(2) Hatton, R. G. " The Influence of Vegetatively Raised Rootstocks upon the Apple, with Special Reference to the Part Played by the Stem and Root Portions in Affecting the Scion." Journ. Pom. and Hort. Sci., 1931, **9**, 265-77.

(3) Knight, R. C. " Preliminary Observations on the Causes of Stock Influence in Apples." East Malling Res. Sta. Ann. Rep. for 1925 (1927) (II—Supplement), 51-63.

(4) Vyvyan, M. C. " The Effect of Scion on Root—III." Journ. Pom. and Hort. Sci., 1930, **8**, 259-82.

THE EFFECT OF SIZE OF TREE ON THE RELATIONS BETWEEN VARIOUS RECORDS OF ROOTS AND STEMS OF APPLES

By R. C. KNIGHT and T. N. HOBLYN

In experimental studies of fruit plants one problem of the investigator has been to express quantitatively the phenomena of growth and cropping which are under examination. Whilst the crop gathered may be counted, weighed and sometimes even measured there are many characteristics of the plant which are not easily rendered in quantitative terms. The " vigour " of a tree, for example, may be expressed by a figure for its total weight, but this cannot be determined while it is growing, and, moreover, it gives no indication of form and distribution of growth. It has consequently been the practice to obtain records of a variety of features of the living tree, such as length of new stems, girth of main stem, and height and spread of the branches (5).

Each of these gives a measure of some character of the tree but it has not yet been possible to obtain a clear idea of the mutual relationships of these different measurements nor how far any of them is representative of total weight. One reason for this is that the unit of plants examined is necessarily reduced to the minimum compatible with the particular object in view, so that it is only infrequently that extensive inter-comparisons of large numbers can be made.

One very important character which has proved difficult of quantitative expression is the form of the root system. In the absence of common standards of comparison, a description is unlikely to provide a complete measure of the subject, even if supplemented by photographs. Particularly is this the case with the character of " fibrousness " which is a significant attribute of rootstocks and which differs widely in different varieties.

Quite apart from the distribution of the smaller roots over different portions of the system there are marked differences in the proportions of " fibre " and this proportion, by weight, has been used as an expression of fibrousness. An arbitrary limit of diameter (1, 2 or 3 mm.) is adopted, the roots below this size are designated " fibre " and their weight is calculated as a percentage of the total weight of roots.

It has been already pointed out (1, p. 255) that figures so obtained must not be interpreted without reference to the size of the whole root system, since it appears, *a priori*, and from the records of relatively small batches of trees, that percentage of fibre may differ considerably according to the size of the root system and irrespective of any differences of stock, scion or treatment. It was indicated (loc. cit.) that a large series of trees was being prepared for a further study of the problem. This series consisted of nearly 400 apple trees on clonal stocks (No. VI). Originally it was intended to try for as wide a range of vigour as possible, and to include all grades of rootstocks. However at the time of budding the only large series available consisted of second grade stocks. Nevertheless a considerable range of vigour was included since every stock large enough to take the bud was used. These were budded with the variety Grenadier

in 1929 and allowed to grow entirely unpruned for two seasons ; they were then carefully lifted during the Winter, 1931-32. Each tree was then analysed in the manner previously indicated (1) in order to obtain the fresh weights of one-year-old stems, two-year-old stems, stem of the stock, roots less than 1 mm. in diameter, roots less than 3 mm. in diameter and other roots. The diameter of the scion stem at a point 10 cm. above the union was also measured.

There is thus available a variety of records of a large number of trees of the same constitution, similarly treated. However by the use of a wide range of size of rootstocks and by the deliberate omission of pruning at the end of the first season, the trees were made to vary considerably more than would usually be the case in order to provide material suitable for the particular purpose in view. The number available has made it possible not only to obtain information regarding the immediate problem of fibrousness, but also to determine to what degree certain of the measurements already referred to are inter-related.

1. Percentage of Fibre and Total Weight of Roots.

The trees were arranged according to the total weight of roots and grouped at 20 gm. intervals (Table I), the frequency curve showing a reasonable approximation to normal. For each group the average percentage weight of roots less than 1 mm. diameter was calculated and the process was repeated for roots less than 3 mm. diameter. The two values were calculated because hitherto in different experiments the arbitrary limit of " fibre " has been variously fixed, according to circumstances at 1 mm., 2 mm. or 3 mm. This method of presentation has been adopted in preference to correlation co-efficients partly because it was used in the previous work and partly for simplicity.

It is evident from Table I that whichever limit is adopted for fibre the percentage decreases steadily with increasing size of root system, which was clearly indicated in the paper already referred to and is now amply confirmed. The relationship may be different for different combinations of stock and scion and for trees of different ages, but the fact that it exists emphasizes the necessity of taking into consideration the size

Table I.

Percentage of Small Roots in Systems of Different Sizes.

No. of Trees.	Average Weight of Roots (gm.).	% Roots under 1 mm. diameter.	% Roots under 3 mm. diameter.
1	25·4	39·8	67·4
15	43·0	19·5	46·8
21	60·0	16·4	40·7
27	81·4	13·8	37·9
50	99·6	10·9	30·6
78	120·2	10·3	28·6
73	139·3	9·1	24·8
48	158·8	8·3	24·1
36	179·5	7·9	23·0
22	198·4	7·0	19·7
11	217·8	6·9	17·2
4	235·6	5·5	14·0

of the root system when attempting to express fibrousness by means of figures of percentage fibre. The further implications of this proviso in relation to particular cases have already been discussed.

2. Stem/Root Ratio and Total Weight of Tree.

For this relationship the trees were arranged according to total weight and grouped at intervals of 50 gm., the average percentage weight of stem being calculated for each group. The proportion of stem, as shown in Table II, is remarkably constant throughout, the maximum variation being from 68·5 per cent. stem to 72·3 per cent. stem among groups which varied in average weight of whole tree from 126 gm. to 816 gm. Other examples of the constancy of the relation of weight of stem to weight of root have been found in studies, as yet unpublished, of trees the size of which has been varied deliberately by cultural treatment.

Table II.

Variation of Different Records with Weight of Tree.

No. of Trees.	Average Total Weight (gm.).	% Stem.	% Scion.	% Stock Stem.	Area of Cross Section of Main Stem (sq. cm.).	Weight of Scion per cm.² Cross Section (gm.).
4	126	69·5	48·2	21·3	0·701	87
13	176	69·2	49·0	20·2	1·167	77
16	227	72·3	52·6	19·7	1·307	92
10	282	71·0	51·9	19·1	1·474	103
28	334	70·9	52·1	18·8	1·829	97
42	379	71·2	53·3	17·9	1·880	108
51	428	71·0	53·6	17·4	2·170	107
55	479	71·0	53·6	17·4	2·377	109
58	523	71·2	54·4	16·8	2·543	113
42	575	69·9	53·3	16·6	2·706	114
34	624	70·5	54·0	16·5	2·963	115
18	677	70·4	54·3	16·1	3·163	116
6	722	69·3	54·8	14·5	3·235	123
5	764	69·8	54·1	15·7	3·293	127
4	816	68·5	54·4	14·1	3·721	120

3. Stock/Scion Ratio and Total Weight of Tree.

The primary division of the tree into root system and stem does not take account of the fact that part of the stem (the " stock stem ") belongs to the stock, and the other part is the scion. In the present observations the scion was weighed separately from the stock stem and Table II shows that there is a small but steady increase in scion weight (expressed as percentage of total weight of tree) and a corresponding relative decrease in percentage weight of stock stem with increasing size of tree. The significance of this in relation to the practical problem of taking records is probably slight, but the matter is further discussed below in considering measurements of diameter.

4. Diameter of Stem and Weight of Scion.

The diameter of the main stem of a young tree or the girth in the case of an older tree is a record which is conveniently and rapidly taken, and from such a measurement is obtained a figure which is a reasonably good relative expression of the area of the cross section of the stem. The outline of the stem is regarded as a circle and the area of this circle, calculated from the measured diameter or circumference is regarded as proportional to the total amount of growth made by the tree. Indeed, Sudds and Anthony (8) regard records of girth of trunk as so valuable and " so closely correlated

to weight and elongation that usually they are the only records which need be taken in studies involving apple tree vigour".

The question has been more fully discussed by Hoblyn (5) who points out that the total length of extension growth is more closely correlated with the area of the cross section of the stem than with the girth. Sudds and Anthony also found this to be the case and Heinicke (4) found that weight of tree increased about 7·3 times when the trunk circumference was doubled. This suggests that although there may be a close correlation between cross sectional area and weight, the relation is not a simple one.

In the present series of trees, the relation has been expressed as the weight of tree (a similar result is obtained whether the whole tree, or scion only is considered) per sq. cm. of cross sectional area of main stem, and this has been calculated for groups of trees of different average weights. The last column of Table II shows that the figure obtained steadily increases with size of tree. The number of trees available of the extreme ranges of size is rather small to compare accurately with Heinicke's figures but calculation shows that a tree with a girth of 2·15 is 6·1 times as heavy as a tree with a girth of unity. If the weight of the tree continues to increase disproportionately to the thickening of the main stem the weight of scion per unit area of stem cross section, which ranges between about 80 and 130 gm. in Table II, should be much larger in older trees. Unfortunately figures for mature trees of Grenadier on VI are not available but some fourteen-year-old Worcester Pearmains on stock No. VI in a rootstock trial (records as yet unpublished) have produced about 300 gm. of scion for each square cm. of cross sectional area of trunk. It must be recorded, however, that Grenadier has been shown to make a tree with a relatively low stem/root ratio (3, 10) and it may be that part at least of the disparity between the above figures for young Grenadiers and mature Worcesters is due to this habit. Further, although the present series of trees were deliberately chosen to represent a wide range of variation, they were all of the same constitution and of the same age, and it would be premature to lay down principles for general application. It does, however, appear that whatever may be the relation between increase in girth and length of extension growth, the total increase in weight of the scion is not wholly manifested in trunk expansion. Indeed, increase in total weight is the result of expansion in three dimensions whilst measurement of cross section concerns only two, but this does not necessarily justify the simple comparison of weight with the cube of the girth in the manner mentioned by Sudds and Anthony.

A similar consideration will explain the decrease in relative weight of stock stem with increasing size of tree which has already been referred to. Stock stem increases in two dimensions only.

From our knowledge of tree growth it would appear unlikely that the cross sectional area should be proportional to weight of head. Furr (2) points out that the trunk of an apple tree has a cross sectional area smaller than the sum of the cross sectional area of the main branches which arise from it. The same has been found to be the case with smaller branches of various sorts of plum and cherry. Measurements of xylem area made on series of cross sections of young branch systems showed that the wood area just below a branch shoot was always considerably less than the sum of that of the two stems immediately above the point of branching. This, of course, is cumulative, passing down the tree, so that the size of the trunk in a large tree falls far short of the sum of the thicknesses of the ultimate branches. This may be associated with the delay in Spring of the commencement of stem thickening in regions distant from growing shoots which results in trunk expansion beginning later in the season than thickening of young stems (6, 9). If then the cross sectional area of a young shoot is a measure of its weight,

it is not to be expected that the cross sectional area of the trunk would be similarly proportional to the total weight.

Hoblyn (l.c.) has discussed the value of various methods of estimating the vigour of the tree and the necessity for simplicity and speed of operation and the matter may so be left, whilst emphasizing that it may be dangerous to accept girth measurements as a satisfactory indication of total weight, even of a tree which has not begun cropping. The factor of fruit production is a further complication which does not enter into the present observations, but it is discussed by Sudds and Anthony (l.c.), Waring (11) and Reed (7).

Summary.

Weights and measurements were taken of the stems and roots of a batch of nearly 400 two-year-old trees of Grenadier on stock No. VI.

Confirmation was obtained of former indications that " percentage fibre " decreases with increasing weight of root system.

Proportion of stem is constant throughout a wide range of size of tree.

The ratio of weight of scion to cross sectional area of main stem increases with the weight of the tree.

References.

(1) Amos, J., Hatton, R. G., Hoblyn, T. N. and Knight, R. C. " The Effect of Scion on Root. II." Journ. Pom. and Hort. Sci., 1930, **8**, 248-58.

(2) Furr, J. R. " The Relation Between Vessel Diameter and Flow of Water in the Xylem of the Apple." Proc. Amer. Soc. Hort. Sci., 1928, **25**, 311-20.

(3) Hatton, R. G., Grubb, N. H. and Amos, J. " Some Factors Influencing Root Development. I. Effect of Scion on Root." E. Malling Res. Sta. Ann. Rep. for 1923, 110-13.

(4) Heinicke, A. J. " Some Relations Between Circumference and Weight and Between Root and Top Growth of Young Apple Trees." Proc. Amer. Soc. Hort. Sci., 1921, **18**, 222-7.

(5) Hoblyn, T. N. " Field Experiments in Horticulture." Imp. Bur. of Fruit Production. Technical Communication No. 2, 1931.

(6) Knight, R. C. " The Relation in the Apple Between the Development of Young Shoots and the Thickening of Older Stems." Journ. Pom. and Hort. Sci., 1927, **6**, 72-7.

(7) Reed, H. S. " Correlations Between Growth and Fruit Production of Apricots." Proc. Amer. Soc. Hort. Sci., 1928, **25**, 247-9.

(8) Sudds, R. H. and Anthony, R. D. " The Correlation of Trunk Measurement with Tree Performance in Apples." Proc. Amer. Soc. Hort. Sci., 1928, **25**, 244-6.

(9) Swarbrick, T. " Studies in the Physiology of Fruit Trees. I. The Seasonal Starch Content and Cambial Activity in One- to Five-year-old Apple Branches." Journ. Pom. and Hort. Sci., 1927, **6**, 137-56.

(10) Vyvyan, M. C. " The Effect of Scion on Root. III. Comparison of Stem- and Root-Worked Trees." Journ. Pom. and Hort. Sci., 1930, **8**, 259-82.

(11) Waring, J. H. " The Probable Value of Trunk Circumference as an Adjunct to Fruit Yield in Interpreting Apple Orchard Experiments." Proc. Amer. Soc. Hort. Sci., 1920, **17**, 179-85.

THE DISTRIBUTION OF GROWTH BETWEEN ROOTS, STEMS AND LEAVES IN A YOUNG APPLE TREE AND ITS POSSIBLE BEARING ON THE PROBLEM OF STOCK EFFECT ON TREE VIGOUR

By M. C. VYVYAN

Introduction.

Most of our knowledge about the effect of factors, such as rootstock, pruning treatment and soil conditions, upon the change in size of a tree are based on annual measurements of stem lengths and trunk girths. This method has been very effective and has some marked advantages over other methods. There is a long dormant period during which strictly comparable measurements can be made, and the successive records can be taken on the same trees year after year as the trees are not damaged by the method of recording.

The method has, however, its limitations ; it takes no account of the leaves, since these have fallen, or of the roots since these are out of sight and cannot be examined without damaging the tree. Yet the leaves and the roots form the most important part of the tree, and it is through their activities during the growing season that the stems are enabled to increase in size.

A good deal has been learnt about roots, their morphology (1), (3) and distribution in the soil (7), (8), and the relation of their weight to that of the stems (1), (3), (4), (5), by the excavation of young or mature trees during winter months. Something has been learnt about the leaf relations of mature trees by measurements of leaf size and distribution in Autumn (10). The root and the leaf investigations, however, were made on different trees and on trees of different scion-stock composition.

It is desirable that these investigations on stems, roots and leaves should be supplemented and co-ordinated by a study of the growing tree as a whole during the Summer months, so that the interrelations of the progressive changes in amount and distribution of roots, stems and leaves may be determined.

Winter measurements have shown *what* effects rootstock, pruning and soil treatment can have on the vigour of a tree. Summer measurements should show *how* these effects are brought about.

The course of shoot growth in Summer can be followed by making successive counts and measurements of the shoots and spurs and of their leaves, whilst root growth and its response to temperature and soil humidity can be followed by using glass-sided trenches and boxes and recording the behaviour of the roots growing in contact with the glass (6). These methods have the advantage of economy in material ; the same trees can be used for successive measurements. They do not, however, yield results in terms of weight.

To determine the changes in the relative weights of roots, stems and leaves during growth, the trees must be dug up and dismembered ; this means that a fresh batch of trees must be used for each successive determination.

A preliminary investigation on these lines was carried out in 1929 and 1930, and a fuller investigation was started in 1930 and brought to a close in 1932. A progress report on the results found up till the Spring of 1931 has been published (9) ; the present paper is a preliminary statement of some of the more important results found in the 1930-32 investigation.

Material and Methods.

One thousand carefully selected rooted shoots from the stool beds of the vigorous apple rootstock Malling No. XIII were used. These shoots were defeathered and cut back to a uniform length of 2 ft. 6 ins. ; such roots as were present were cut back to about 4 ins. Each " tree " was weighed individually and the diameter of its stem determined at two points.

Fifty of these " trees " were selected at random and used as an initial sample to determine the dry weights of stems and roots at the time of planting ; the remainder were planted out at a uniform depth of 6 ins. at the beginning of April, 1930.

At intervals during the course of the next two years samples of fifty or twenty-five trees were lifted, with as much of their roots intact as possible. There were eighteen such " harvests " in addition to the initial sample, the last sample being harvested on 3rd May, 1932.

Each lifted tree was washed, to remove the soil, then weighed as a whole to determine the fresh weight. It was then dismembered into stem, leaf and root ; the stems being further subdivided according to their year of origin into 1929, 1930 and 1931 " wood ", and, according to their length, into spurs and shoots : the leaves were subdivided into " spur " leaves and " shoot " leaves. The fresh and dry weights of each of these parts of the tree were determined separately.

Certain other records were taken, such as the lengths and diameters of the stems and the numbers of the leaves, but these will not be discussed in the present report.

The Results.

The only results that will be described and discussed in this report are those that refer to the progressive change in the total weight of the tree and of its parts, the changes in the relative weights of stems, roots and leaves, and the relative rates of growth of different organs at different times of the year and during different seasons.

Progressive Changes in Weight of Tree and of its Parts.

The total dry weight of the tree at the time of the successive harvests is shown on Fig. 1 as a heavy black line. The shaded portions at the top and bottom of the figure represent the dry weights of the leaves and of the roots respectively, whilst the intermediate unshaded portion represents that of the stems. The weight of stems has been further subdivided into that of the 1929 stem or trunk, that of the branches formed in 1930 and that of those formed in 1931.

The time of year is indicated by the initial letter of the month at the base of the figure.

For reasons explained in the previous report, the values plotted are the dry weights on the basis of the original fresh weights, that is to say, the values of the mean dry

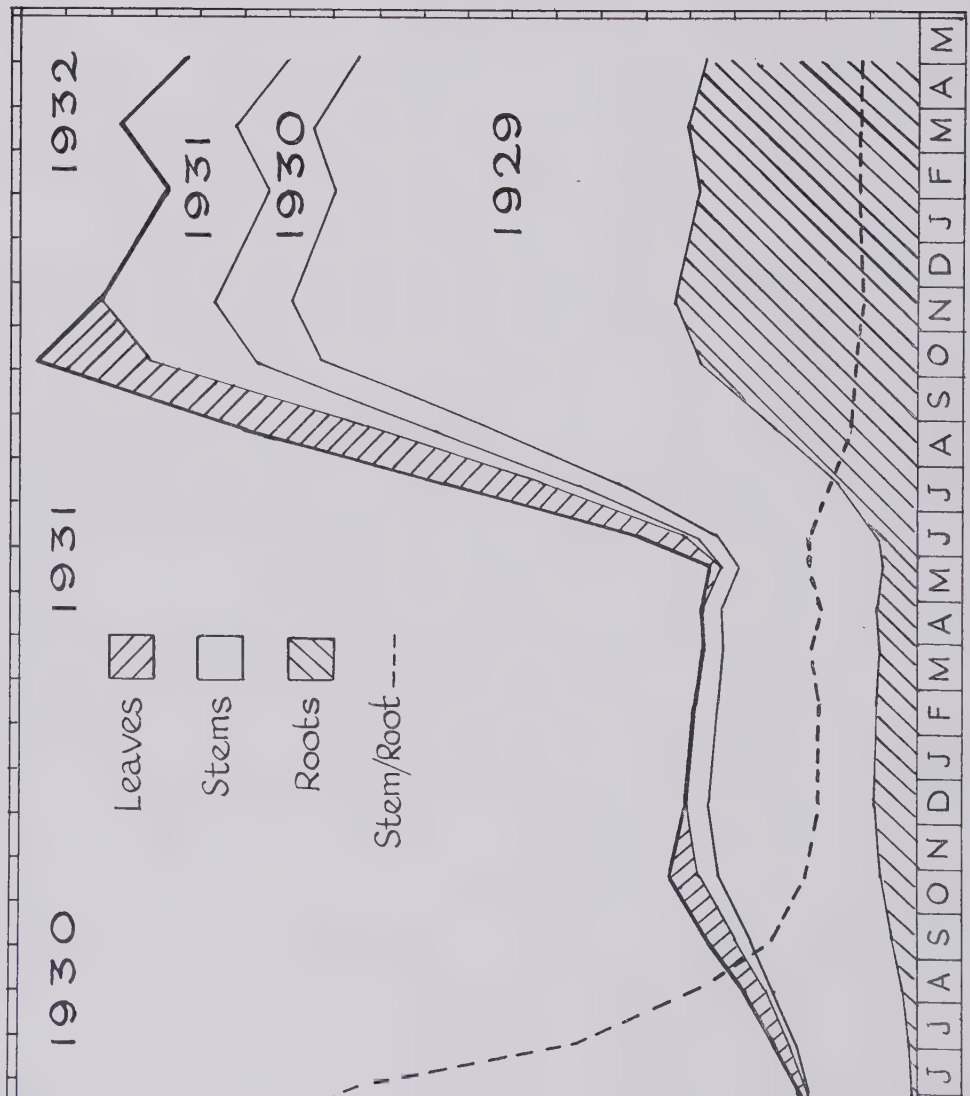


FIG. 1.

Mean Dry Weight of the tree and of its leaves, stems and roots at the time of the successive harvests during the first two years after planting. The broken line represents the stem/root ratio, plotted as dry weight of stems per 100 gms. of roots.

weights for each sample harvested have been multiplied by 100 and divided by the mean fresh weight of that sample at the time of planting.

It will be seen that the total weight of the tree increased, as might be expected, during the growing seasons from May till October. Between the October harvest and the last harvest of the season, which in 1930 was taken at the beginning of December and in 1931 at the end of November, the total dry weight decreased owing to leaf fall, though the dry weights both of stems and of roots increased somewhat during that period. During the Winter and Spring months the dry weights of the stems and of the roots both tended to decrease, though they showed some fluctuations.

The Stem/Root Ratio.

The relative weights of stems and roots can be conveniently expressed as a ratio by dividing the weight of the stems by that of the root; this ratio is known as the stem/root ratio.

There is considerable evidence that this ratio tends to be a constant for any particular scion-stock combination, growing on any particular soil, though the value of the constant varies considerably with the variety used as the scion, and very greatly with the soil. Rootstock has not yet been found to have much effect on its value.

For reasons that will be discussed more fully in a later section (vide p. 128), this ratio is of considerable interest in connection with the problems of stock effect, response to pruning, and response to soil conditions.

The values of this stem/root ratio are plotted on Fig. 1 as a broken line. At the time of planting, in April, 1930, the value was very high; there were about 33 grammes of stem for every gramme of roots. By the beginning of December, 1930, it had fallen to about 4·3 and by the end of November, 1931, it had fallen still further to a value of about 2·4.

A change of this type in the stem/root ratio might be expected, for, up to the time of their removal from the stool bed, the shoots had been attached to the parent plants and had been in connection with the roots of these plants as well as with their own. When removed from the stool bed they were detached from these plants, the process of removal constituted, therefore, in practice a very severe form of root pruning. The change in stem/root ratio may be regarded as the gradual restoration of the normal value of that ratio as the trees became established on their own roots.

Examination of the distribution, between stems and roots, of the new weight added during growth, show how this change in the ratio was brought about.

Relative Increments in Weight of Roots, Stems and Leaves.

If the weight found at the beginning of a period of growth is deducted from that found at its end, the difference represents the "increment" or amount of new weight added during the period. Thus the dry weight of roots was 1·55 grammes in April, 1930, and 15·86 grammes in October, the increment in root weight between April and October, 1930, was therefore 14·31 grammes.

The increments in weight of roots, stems and leaves between April and October, of 1929, 1930 and 1931 are given in columns 2, 3 and 4 of Table I. The values for 1929 are those found in the preliminary investigation carried out that year and described in the former report (9). They are included here for comparison.

In columns 5, 6 and 7 of the same Table, these increments are expressed as percentages of the total yearly increment in tree weight, so as to bring out the relative values of the increments in weight of roots, stems and leaves.

TABLE I.

ACTUAL AND RELATIVE INCREMENTS IN DRY WEIGHTS OF ROOTS, STEMS AND LEAVES DURING THE PERIOD APRIL-OCTOBER IN 1929, 1930 AND 1931.

	Actual Increments* (in grammes).			Relative Increments (as Percentages of Total).		
Year	1929.	1930.	1931.	1929.	1930.	1931.
Age	1	1	2	1	1	2
Roots ..	15·68	14·31	78·18	25·8	25·4	25·6
Stems ..	31·54*	29·26	170·26	52·0	51·9	55·8
Leaves ..	13·46	12·85	56·76†	22·2	22·7	18·6
Total ..	60·68	56·42	305·20	100·0	100·0	100·0

* These values are on the basis of grammes dry weight per 100 grammes fresh weight at time of planting. As the fresh weights, but not the dry weights, of the stems of the trees in April, 1929 were known, it has been assumed that the dry weights per 100 grammes fresh weight was the same as that found for the stems of trees of the same age planted the same month in 1930.

† This value represents the amount of leaf found at the harvest on the 20th August. The value for October was lower, owing to some leaf fall, but it is obvious that the highest value found is the best index of the total amount of leaf formed.

It will be seen that the relative increments in weight of roots was almost identical in the three seasons ; it was 25·8, 25·4 and 25·6 per cent. of the total increment in 1929, 1930 and 1931 respectively. This very close similarity in value is all the more striking when the differences in the treatment and in the size of the trees are remembered. In 1929 the trees were planted in April without any roots, all those that had developed in the stool bed being removed. In 1930 the trees were planted in April with such roots as they had developed, though these were trimmed back in accordance with the normal practice. In April, 1931, the trees had been undisturbed for a whole year and had already developed considerable root systems.

The "actual values" of the increments given in Table I are on the dry weight per 100 grammes initial fresh weight basis and as already shown (9) the values for the 1929 and 1930 trees were very similar on this basis. In actual size the trees were very different in the three years. The mean fresh weights in April, 1929, 1930 and 1931 were 10·00, 70·4 and 138·6 grammes respectively, and the corresponding values in October were 24·3, 149·9 and 465·8 grammes respectively. Thus the trees harvested in October, 1931, were nearly twenty times as large as those harvested in October, 1929, yet the relative increment that had been added in the form of root was practically identical in the two years.

The percentage distribution of new weight between stems and leaves was almost identical in 1929 and 1930, but was a little different in 1931.

Knight (4), (5) has shown that the percentage distribution of weight increase between stems and roots tends to be a constant in trees of a given scion-stock combination, irrespective of the degree of branch pruning. He did not obtain the weights of the leaves. The results summarized in Table I are further evidence in the same direction and extend Knight's concept of a constant proportionate distribution of new weight to include the leaves as well as the stems and roots.

These results indicate how a constant stem root ratio is attained and maintained. If the ratio (stem increment) (root increment) is a constant, the value of the stem root

ratio must tend to take up the same value, as the sum of the successive increments becomes progressively an ever larger proportion of the total weight of the tree.

Mean Annual Rate of Growth of the Tree and of its Parts.

As the stem/root ratio progressively fell, it necessarily follows that the roots must have been growing faster than the stems, e.g. they must have taken less time than the stems to double in weight, for they were gaining in relative weight. As the stem/root ratio gradually approximated towards a constant, however, the difference between the rates of growth of roots and stems must have become progressively less, because when the stem/root ratio remains constant it means that both organs are growing at the same rate ; the numerator (stems) and the denominator (roots) are both doubling in the same length of time.

These conditions would be equally well satisfied, however, whether the rate of stem growth remained constant and that of the roots gradually fell to the same value, or whether that of the roots remained constant and that of the stems gradually increased to the same value. Alternatively the rate of growth of one might increase and that of the other decrease.

It is of some importance to know which of these alternatives holds good, for if either organ is found to grow at a constant rate it will be an indication that it is that organ that is regulating the total rate of growth.

The most convenient method for calculating a rate of growth is that based on the concept of compound interest. The weight of the tree or organ is regarded as " capital " which is adding to itself at a " rate of interest " ; the amount being added at any moment being determined by the amount of " capital " at that moment and by the " rate of interest ".

Given the weights at the beginning and end of a period and the length of the period, it is possible to calculate the mean rate of interest, or growth, during that period.*

The values of the rates of growth, calculated on this basis, for roots, stems, shoots (i.e. stems plus leaves) and total tree weight are given in Table II.

Table II.

Mean Percentage Rates of Increase in Weight, on Compound Interest Basis, for Roots, Stems, Shoots (i.e. Stems + Leaves) and Total Tree, During Growing Seasons of 1930 and 1931.†

Year.	Age.	Roots.	Stems.	Shoots.	Tree.
1930	1	251	48	63	78
1931	2	179	120	140	148

* The formula equation used was West, Briggs and Kidd's (11) modification of Blackman's (2) equation, i.e.

$$\log_e W_1 - \log_e W_o = \frac{Rt}{100}$$

where W_o is the weight at the beginning of the period, W_1 the weight at the end of the period, e is the base of natural logarithms, t the length of the period and R the required mean rate of growth.

† The period was from April till the beginning of December (1930) or the end of November (1931), each period has been regarded as a single unit of time as it comprised a whole growing season, i.e. " t " in the equation has been given the value " 1 ". The leaf weights included when calculating the rates for shoots and total trees were the highest values of leaf weight found in the season as these values are obviously the best measure of the total amount of leaf formed.

The rate of root growth was rather less in 1931 than in 1930, but the rates of shoot growth and of stem growth very much greater. The fall in the growth rate of the roots was very much less than the rise in the rate of growth of the shoots, indicating that it was the amount of root that was determining the rate of growth in each case and that the shoots were not increasing at their full rate in 1930 owing to lack of roots. The fall in the root growth rate in 1931 may be due to an increasing effect of the shoots upon the rate of growth as the relative amount of shoot gradually approached the normal value, or it may be due to a gradual increase of the amount of " unproductive capital " in the roots as these thickened up. In the latter case, however, a similar fall in the rate of growth might have been expected in the shoots, for these, too, must have thickened up.

Rates of Growth of Stems and Roots at Different Times of Year.

The rates of growth of the stems and roots at different times in the year are shown in Fig. 2, where they are superimposed but distinguished by different kinds of shading. The width of each column represents the period of time between two successive harvests, the height the mean rate of increase in dry weight during that period, calculated on the compound interest basis. As the rates differed from period to period, it is obvious that they must have been changing during the periods too. Only the mean values of these changing rates can be calculated, however, and this is indicated by the horizontal lines at the tops of the columns. If it had been possible to take harvest at shorter intervals, say once a week or even once a day, the columns would have been split up into a number of narrower ones, each with its own flat top, and these flat tops would have tended to merge into a semblance of a continuous curve.

The close similarity of the rates of growths of the roots in the two seasons and the marked difference between those of the stems is brought out clearly by this figure.

In both roots and shoots the rate of increase in weight was greatest in June and July, the rate then fell off progressively as the season advanced.

Discussion.

Although it would be premature to draw more than very tentative conclusions from the results of this investigation, which was confined to unworked trees of a single stock and to two seasons of growth, the results, taken in conjunction with those from other investigations, do seem to suggest the possible nature of one of the links in the mechanism responsible for the reciprocal effects of scion and stock on tree vigour.

Excavations of mature trees at East Malling and elsewhere have shown (7), (8) that for a given scion variety (Lane's Prince Albert) on a given soil, the stem/root ratio is remarkably constant, irrespective of the size of the tree. Thus at East Malling there were about $2\frac{1}{2}$ lbs. of stem for every lb. of roots, whilst at Wisley there was rather less than 1 lb. of stem for 1 lb. of roots. These ratios were approximately constant, though the size of the tree varied enormously according to the nature of the rootstock upon which it was worked. Other work on younger trees has yielded similar results, but has shown that the value of the constant varies somewhat with the variety used as scion. For example the value is always lower for Grenadier than for Beauty of Bath (3), (1).

Now there are two occasions at least in the life of a tree when the stem/root ratio must be arbitrarily changed ; removal of the stock from the stool bed constitutes very severe root pruning and must increase the value of the stem/root ratio, whilst the removal of the stock stem in the maiden year, after the scion bud has begun to grow, constitutes very severe stem pruning and must lower the ratio. The value characteristic of a given

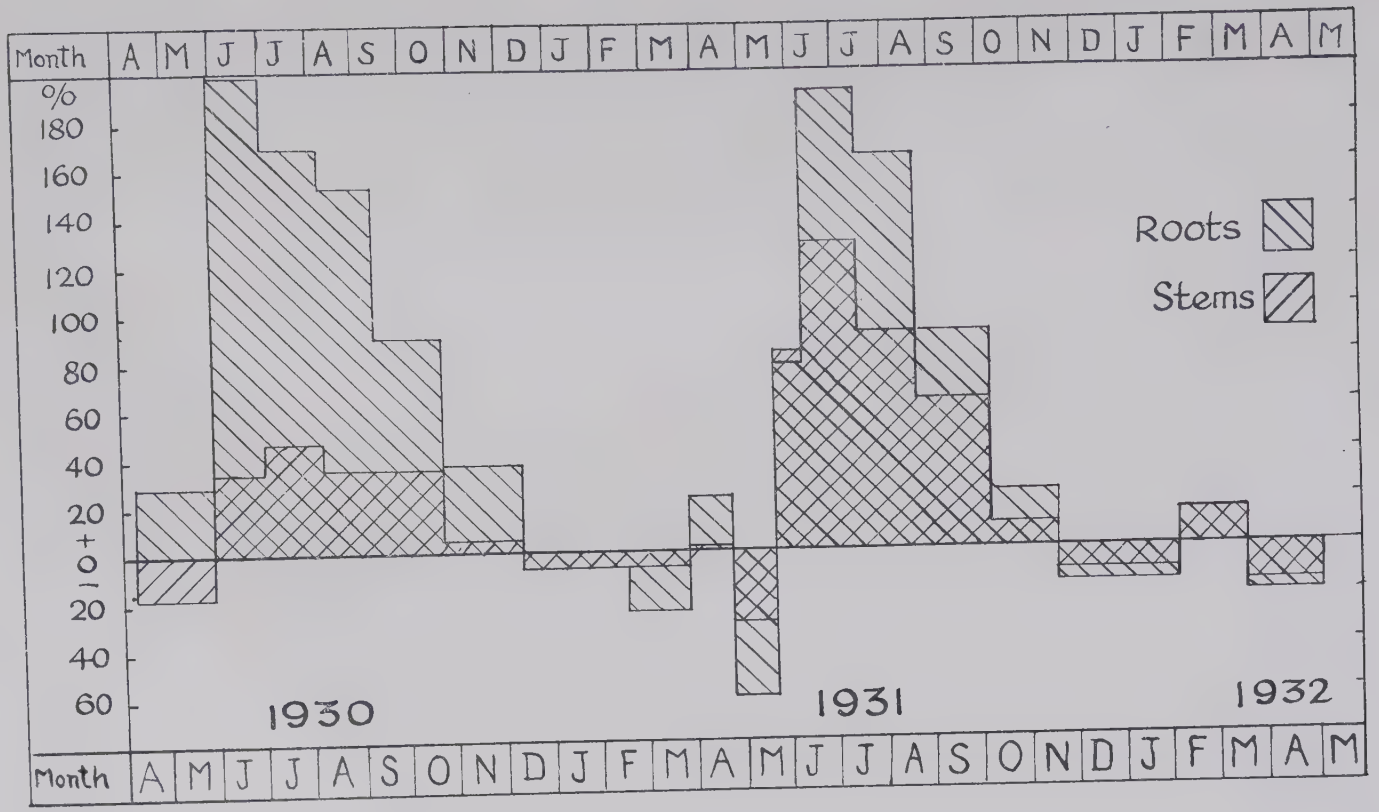


FIG. 2.

Mean rates of growth of stems and roots during periods between successive harvests.

scion-stock combination must not only be kept constant when established, but must be re-established when it has been arbitrarily changed.

Knight's work (4) has shown that the ratio of (stem increment)/(root increment) is a constant within a given scion-stock combination on East Malling soil, and that this is a sufficient explanation for the establishment of a constant stem/root ratio.

The results described here indicate that a similar constant ratio may possibly exist between increments of leaf and root and leaf and stem.

Both Knight's results and those described here refer to the re-establishment of the stem/root ratio after severe root pruning, but it seems probable that the mechanism for its re-establishment after severe branch pruning will be the same. Experiments are in progress to determine if this is the case.

Can it be that this obligatory (stem increment)/(root increment) ratio, or perhaps (stem increment) : (root increment) : (leaf increment) ratio is an important part of the mechanism of stock influence on the vigour of the scion.

A constant ratio between two organs means that both are growing at the same rate, e.g. both are taking the same length of time to double in weight.

It is well established that different varieties of plants may have different rates of growth ; what is going to happen when two varieties with different innate growth rates are combined as scion and stock in a single tree ? Once the constant ratio between them has been established, both must grow at the same rate. Either the slower variety must speed up its rate or the faster variety must slow down its rate, most probably they will compromise by both taking up some intermediate value.

As one of the varieties would be the scion and the other the stock, it follows that either the scion would be influencing the vigour of the stock or the stock that of the scion or they would be mutually influencing one another's vigour. This is in accordance with the observed facts of stock influence.

The problem of stock influence would not be solved, of course, but it would cease to be a problem *sui generis* and would become one aspect of a larger problem, for the constancy of the stem/root ratio would prove to be a factor common to the mechanism of pruning response, soil influence and stock-scion relations.

The hypothesis outlined above, in its present tentative form, offers no explanation for stock influence on precocity or for special forms of stock influence such as the liability of the scion to leaf scorch or disease. Even in the case of effect of stock on vigour there are apparently anomalous cases where two stocks have different relative effects according to the scion worked on them and where the relative effects of the stocks change with the increasing age or size of the trees.

The hypothesis is fortunately one that can easily be put to the test, and experiments for this purpose are in progress.

Summary.

The course of growth of stems, roots and leaves in an apple stock has been followed during the first two years after planting by digging up, dismembering and weighing successive batches of trees at intervals of a few weeks.

The total annual increment in weight was found to be distributed in approximately constant proportions between roots, stems and leaves, irrespective of the size and age of the trees. This extends Knight's concept of a constant ratio of stem increment to root increment to include the leaves.

It is pointed out that this explains how the constant stem/root ratio found in trees of a given scion-stock combination on a given soil is attained and maintained.

It also suggests a mechanism for some aspects of scion and stock effect on vigour.

A constant stem/root ratio means that stem and root are both growing at the same rate, e.g. both must take the same time to double in weight. If a vigorous or fast growing variety is combined with a dwarf or slow growing one as scion and stock in a single tree, they must adjust their rates of growth to a common value, thus scion and stock may be expected mutually to affect one another's rates of growth in a manner similar to that actually observed.

Literature Cited.

(1) Amos, J., Hatton, R. G., Hoblyn, T. N. and Knight, R. C. "The Effect of Scion on Root. II. Stem-worked Apples." Journ. Pom. and Hort. Sci., 1930, 8, pp. 248-58.

(2) Blackman, V. H. "The Compound Interest Law and Plant Growth." Ann. Bot., 1919, 33, p. 353.

(3) Hatton, R. G., Grubb, N. H. and Amos, J. "Some factors influencing Root Development. I. Effect of Scion on Root." E. Malling Res. Sta. Ann. Rep. for 1923, pp. 110-13.

(4) Knight, R. C. "The Influence of winter stem pruning on subsequent Stem and Root Development in the Apple." Journ. Pom. and Hort. Sci., 1934, 12, pp. 1-14.

(5) Knight, R. C. and Hoblyn, T. N. "The Effect of size of tree on the relations between various Records of Roots and Stems of Apples." E. Malling Res. Sta. Ann. Rep. for 1933 (May, 1934).

(6) Rogers, W. S. "Root Studies. IV. A Method of observing root growth in the field; illustrated by observations in an irrigated apple orchard in British Columbia." E. Malling Res. Sta. Ann. Rep. for 1933 (May, 1934).

(7) Rogers, W. S. and Vyvyan, M. C. "The Root systems of some ten-year-old Apple Trees on two different Rootstocks, and their relation to tree performance." E. Malling Res. Sta. Ann. Rep. for 1926-27 (II. Supplement), 1928.

(8) Rogers, W. S. and Vyvyan, M. C. "Root Studies. V. Rootstock and Soil effect on Apple Root Systems." Journ. Pom. and Hort. Sci., 1934 (at the Press).

(9) Vyvyan, M. C. "Course of Growth in an Apple Stock during the maiden year." E. Malling Res. Sta. Ann. Rep. for 1928, 1929 and 1930 (II. Supplement), 1931.

(10) Vyvyan, M. C. and Evans, H. "The Leaf relations of Fruit Trees. I. A Morphological Analysis of the Distribution of Leaf Surface on two nine-year-old Apple Trees (*Laxton Superb*)." Journ. Pom. and Hort. Sci., 1932, 10, pp. 228-70.

(11) West, C., Briggs, G. E. and Kidd, F. "Methods and significant relations in the quantitative analysis of Plant Growth." New Phyt., 1920, p. 19.

HOPS

CULTURAL TRIALS WITH HOPS I

THE EFFECT OF DISTANCE OF PLANTING AND NUMBER OF BINES PER STRING—A PROGRESS REPORT

By F. H. BEARD

In 1926 it was decided to lay down various cultural trials as available material and land permitted, but it was not until the Spring of 1928 that it was possible to commence the first of the trials.

Results obtained from a series of manurial experiments with hops at East Malling indicated that in cases where certain of the plants in a plot were killed by disease the yield per hill of those remaining was materially increased owing to the wider spacing (1).

In view of these results a trial was laid down in order to ascertain the effect on the cropping of three distances between the hills, and at the same time to investigate the effect of varying the number of bines trained up each string.

The variety selected for the trial was the early seedling L21 (Tolhurst × English Male) raised by Prof. Salmon. This variety is naturally a rather weak grower, making few " heads " over the top wire, but it tends to crop over the whole length of bine from the breast wire upwards, and gives quite good crops for an early variety.

It is immune to the " Mosaic " disease and very resistant to the hop " Downy Mildew " (*Pseudoperonospora humuli*), and is immune as regards attacks on the cones by the latter disease.

The trial is divided into four blocks and one 30 ft. row of each treatment occurs at random in each block. Guard hills are situated at the beginning and end of each experimental row.

The hops are trained on wirework of the " Butcher " system with the rows 7 ft. apart; the top and middle wires are 13 ft. 6 ins. and 4 ft. 6 ins. respectively from the ground.

Three strings are placed to each hill.

The hills are cut (dressed) normally in March and the rank bine is " pulled " before training.

Treatments.

A. Hills 9 ft. apart in the rows and one bine trained up each string.
B. Hills 6 ft. apart and one bine per string.
C. Hills 3 ft. apart and one bine per string.
D. Hills 9 ft. apart and two bines per string.
E. Hills 6 ft. apart and two bines per string.
F. Hills 3 ft. apart and two bines per string.
G. Hills 9 ft. apart and three bines per string.
H. Hills 6 ft. apart and three bines per string.
K. Hills 3 ft. apart and three bines per string.

Cropping.

The weight of green hops from each plot was weighed separately in 1930. This gave significant differences due to distance only. In subsequent seasons the cropping has been sufficiently heavy to allow the separate drying of the crop from each plot. The recording of the weight of dried hops has provided a much more accurate method of estimating the yields, and the taking of green weights was discontinued in 1933.

The cropping of plots in the same treatment has so far been very uniform.

In every season the plots in Series A (9 ft. one bine) have yielded the lightest crop, with an average of 13·53 cwt. per acre for the three seasons. At the other end of the scale comes Series K (3 ft. three bines) with an average yield of 25·16 cwt. per acre.

Table I.

Average Yields 1931-33.

Series Treatment.	1931.	1932.	1933.	Mean 1931-33.
	Cwt. per acre.	Cwt. per acre.	Cwt. per acre.	Cwt. per acre.
A 9 ft. 1 bine	12·19	16·36	12·04	13·53
B 6 ft. 1 bine	18·67	20·53	16·98	18·73
C 3 ft. 1 bine	23·15	26·24	21·14	23·51
D 9 ft. 2 bines	15·90	19·14	16·67	17·24
E 6 ft. 2 bines	19·45	24·08	19·91	21·15
F 3 ft. 2 bines	23·77	27·16	21·45	24·13
G 9 ft. 3 bines	14·51	18·52	16·67	16·57
H 6 ft. 3 bines	22·22	25·47	19·45	22·38
K 3 ft. 3 bines	24·39	29·63	21·45	25·16
General Mean	19·36	23·01	18·42	
S.E.	1·168	1·027	1·137	
Significant Difference	3·410	2·998	3·315	

Table I gives the mean yield for each treatment for the three seasons. Series C (3 ft. one bine), E (6 ft. two bines), F (3 ft. two bines), H (6 ft. three bines), and K (3 ft. three bines) have all cropped well. Series A (9 ft. one bine), B (6 ft. one bine), D (9 ft. two bines) and G (9 ft. three bines) have all given rather low yields.

The heaviest crops were obtained in 1932 when fewer bushels of green hops were needed to yield a cwt. of dried hops, than in either 1931 or 1933.

Effect of Distance Apart of the Hills.

In each season the differences in cropping due to distance of planting have been most marked, and have been consistently in favour of closer planting; this is shown clearly in Table II. Where the hills are 9 ft. apart the average yield has been only 15·78 cwt. per acre, whilst the hills 6 ft. and 3 ft. apart have averaged 20·75 cwt. and 24·26 cwt. respectively.

Although the yield per plot is increased by closer planting the *yield per hill* has been considerably increased by the wider spacing. Where the hills are 9 ft. apart they have had a mean crop of 2·56 lbs. per hill for the three seasons, those at 6 ft. 2·24 lbs., and those at 3 ft. apart only 1·31 lbs. per hill.

Effect of the Number of Bines per String.

The number of bines has not had nearly such a marked effect as distance of planting. One bine per string has had an average crop of 18·6 cwt., two bines has given 20·83 cwt.

and three bines 21·37 cwt. per acre. The difference between one and two bines is significant, but not that between two and three bines. Table III gives the yields for numbers of bines only.

The failure of three bines to give any significant increase over two bines may possibly be due to the difficulty with the variety L21 in obtaining three good bines. In most cases the third bine is weaker and of later origin than the other two. It is hoped to repeat this part of the experiment on a more vigorous seedling in the near future.

TABLE II.

DISTANCE ONLY.

Distance.	1931.	1932.	1933.
	Cwt. per acre.	Cwt. per acre.	Cwt. per acre.
9 ft.	14·20	18·01	15·13
6 ft.	20·13	23·35	18·78
3 ft.	23·76	27·68	21·35
General Mean	19·36	23·01	18·42
S.E.	0·6729	0·5931	0·6562
Significant Difference	1·969	1·731	1·916

TABLE III.

NUMBER OF BINES ONLY.

	1931.	1932.	1933.
	Cwt. per acre.	Cwt. per acre.	Cwt. per acre.
1 bine	18·03	21·04	16·72
2 bines	19·69	23·46	19·34
3 bines	20·37	24·54	19·19
General Mean	19·36	23·01	18·42
S.E.	0·6729	0·5931	0·6562
Significant Difference	1·909	1·731	1·916

SIZE OF CONES.

In 1931 it was noticed that the cones on certain plots were very much better developed and riper at time of picking than other plots. In order to obtain some measure of this variation, two random samples of the picked cones were taken from the bins from two plots in each treatment.

Five hundred cones were counted out from these samples and graded into four grades; under 2 cm. long, 2 to 2·5 cm., 2·5 to 3 cm., and over 3 cm. long. Table IV gives the percentage of cones over 2·5 cm. long in 1931 and 1932.

The cones were very well developed on the plots in Series A (9 ft. one bine) and B (6 ft. one bine); moderately well developed in Series C (3 ft. one bine); D (9 ft. two bines); E (6 ft. two bines) and G (9 ft. three bines). They were poorly developed in Series F (3 ft. two bines), H (6 ft. three bines) and K (3 ft. three bines).

There was a big difference between the size of cones on hills 3 ft. and 6 ft. apart, but the difference between 6 ft. and 9 ft. was not significant.

In 1931 the size of cones at 9 ft. was almost double that at 3 ft. Where only one bine is trained up each string the cones are definitely larger than where two or three are trained up, but the difference between two and three bines is not significant.

In 1932, which was a warmer and more sunny season, the cones on all plots appeared to the eye to be very well developed, but it was decided to again grade samples of cones to see if there was any difference in the size. Two samples of cones were taken from three plots in each treatment and 250 cones from each were graded as before. There was a very high percentage of cones over 2·5 cm. long in all treatments (see Table IV). Whilst in 1931 Series K (3 ft. three bines) had only 14 per cent. of cones over 2·5 cm. long, in 1932 it had 53·73 per cent.

TABLE IV.

SIZE OF CONES. PERCENTAGE OVER 2·5 CM. IN LENGTH.

	1931.			1932.		
	9 ft.	6 ft.	3 ft.	9 ft.	6 ft.	3 ft.
1 bine	32·1	34·9	22·4	67·07	68·17	58·05
2 bines	24·6	19·1	10·6	63·32	64·87	50·65
3 bines	24·7	13·9	10·1	62·52	58·72	53·73
	General Mean 21·38 S.E. 4·6 Significant Difference 13·4			General Mean 60·787 S.E. 2·2186 Significant Difference 6·306		

Notwithstanding this great increase in the size of cones it is interesting to note that the relative positions of the treatments remained almost unchanged.

Samples were cut from pockets of the various treatments in 1931 and kindly judged by Mr. C. G. Tosswill of Messrs. Wigan, Richardson & Co., who assessed the samples from the plots with well developed cones to have the higher market value.

In each season samples of dried cones from the two extreme treatments (9 ft. one bine and 3 ft. three bines) have been analysed by Mr. A. H. Burgess of the South-Eastern Agricultural College. In each season the hops from the 9 ft. one bine plot have been slightly the richer in preservative value. This increase is possibly due to the cones in this treatment being rather riper.

DISCUSSION OF RESULTS.

As records have now been obtained for the cropping over three seasons of very different climatic conditions, it seems fairly safe to regard the results so far obtained as likely to remain with only slight seasonal modifications.

In every season the hills planted at 3 ft. apart in the rows have given the highest yields; but in 1931 which was a cold and wet season, this was associated with poorly developed cones where more than one bine was trained up each string. The 3 ft. plant with one bine per string has given very heavy crops with moderately well developed cones. The increase in weight over that of the 6 ft. plant with two bines is, however, probably not sufficient to cover the additional cost of cutting, pulling, stringing, etc., as well as the initial outlay on the extra sets.

The more common commercial plant of 7 ft. × 6 ft. with two bines per string appears to be the most satisfactory. It has yielded an average crop of over a ton to the acre, whilst in 1931 the cones almost equalled in size those of the 3 ft. and one bine plots.

The variety L21 is unable to make full use of as great a distance as 9 ft. between the hills. It is intended to use this distance with a very vigorous variety as soon as material is available.

The trial has also shown that the number of bines trained up each string has much less effect on the yield than the distance between the hills, the average crop for the 6 ft. one bine plots has only been 2·42 cwt. per acre less than that of the 6 ft. two bines plots ; and the cones on the former were nearly twice as large in 1931. Where the hills are 3 ft. apart the average difference in yield between one and two bines per string is only 0·62 cwt. per acre, which is too small to be significant.

This information should be of interest to growers who fear a severe drop in their crop consequent upon the reduction in the number of bines, due to an attack of the " terminal spike " form of Downy Mildew.

Whilst growers have probably arrived at a fairly satisfactory distance apart for planting existing commercial varieties, the whole new range of vigour possessed by Prof. Salmon's seedlings makes it necessary to review the question of distance of planting and numbers of bines trained up, in the light of the character of the particular varieties to be tested.

Acknowledgments.

The writer is indebted to Mr. T. N. Hoblyn for assistance in the planning of the trial and for the statistical analysis of the records in 1931 ; also to Miss J. L. Edgar for analysing the figures in 1932 and 1933.

The laborious task of grading the cones was undertaken by Messrs. H. M. Tydeman and J. B. Collard in 1931, and Messrs. E. G. Ing and A. C. Faberge in 1932.

Summary.

The first of a series of cultural trials with hops was planted in 1928, and the records of three seasons' cropping are here presented. The experiment consists of a trial of three distances (9 ft., 6 ft., 3 ft.) between the hills in the rows, combined with a trial of different numbers of bines per string (one, two and three bines).

The data so far obtained show :

1. That the yield per acre is greatly increased by closer planting.
2. The yield per hill is increased by wider spacing of the hills.
3. The number of bines per string has had less effect on the yield than the distance of planting, but two bines per string has given heavier yields than one bine.
4. The size of cone and consequent quality of the crop may be materially affected by the treatments in certain seasons.

The results are discussed with a view to deciding on the best treatment for the variety, under commercial conditions over a period of years.

Reference.

(1) Amos, J. and Hoblyn, T. N. " Manurial Trials with Hops." E. Malling Res. Sta. Ann. Rep. for 1926-27 (Oct., 1928) (II. Supplement), 165-71.

BIOCHEMISTRY

TREE INJECTION—A PROGRESS REPORT

By W. A. ROACH

In a chemical investigation of the effect of rootstock on scion it was found that the proportions in which apple trees absorbed their twenty-odd mineral elements from the soil varied from rootstock to rootstock and that the composition of a given scion variety varied according to the rootstock on which it was worked (2). In order to determine how far the effect of the rootstock on the horticultural character of the scion was due to its effect on the mineral composition of the scion it was necessary to test the effect of each element on apple trees. Injection of the substances directly into trees seemed likely to be the best method for this purpose (3), but before the method could be so used experiments had to be carried out to ascertain how far the effects of injecting nutrients into trees resembled those resulting from applying them to the soil as manure.

The results so far obtained suggest that the method is suitable for this and many other research purposes and that, in addition, it may in the future be of more directly practical value; it may possibly be employed in commercial plantations to determine what artificial manures are lacking; and it is within the realms of possibility that the injection of whole plantations may become an economical method of supplying to the trees substances which are either slow acting or are changed in the soil when applied as manure. A short account of the progress so far made along these last two lines may be of interest.

Recognition of Manurial Deficiencies.

(*a*) *By Chemical Analysis.* For a century attempts have been made to determine by chemical analysis what manures plants need. Liebig analysed different kinds of plants and advised manuring each kind with those substances occurring most abundantly in it. Actual manurial trials carried out by Lawes, however, showed that the problem was not so simple as Liebig supposed. Turnips, which contain relatively little phosphate, should, according to Liebig, require little phosphate as manure, whereas Lawes' experiments showed that turnips actually required relatively large quantities of phosphate. It was soon realized that in order to determine what manures to apply, the kind of soil in which the crop was growing had to be taken into account because the composition of a plant varies according to the soil in which it is growing and because what would be a good dressing on soil of one type would be quite inadequate on another.

Much work has been done on the composition of soils. To analyse the whole soil was soon found to be of little or no use because most of the solid part cannot be used by plants. Many attempts have been made in the past, and are still being made, to dissolve from soils just those substances which the plant is able to absorb from them. Some of these methods are useful, but none of them has been found to be of straightforward application. One serious complication arises from the fact that plants show remarkable differences in ability to abstract nutrients from the soil; thus apple trees on No. V rootstock at the Research Station show marked symptoms of potash deficiency, whereas

trees of the same variety on other rootstocks interplanted with them make healthy growth.

(*b*) *By Leaf Symptoms, etc.* Perhaps the most useful single method for deciding what manures are necessary is a study of the trees themselves, particularly of the leaves. Wallace (5, 6) as a result of pot experiments at Long Ashton has been able to recognize manurial (especially potash) deficiencies in various parts of the country by the appearance of the leaves, etc. In an experiment to be mentioned later (p. 139), however, a tree which showed no leaf or other "deficiency" symptoms responded strongly to an injection of potassium nitrate. This result suggests that absence of deficiency symptoms does not necessarily mean that the tree is receiving the best possible nourishment.

The above facts illustrate some of the difficulties in deciding on the best system of manuring for a plantation. Often after every available method has been used there is still uncertainty as to what is the best course to follow.

(*c*) *By Manurial Trials.* Obviously the most certain way to find out the best system of manuring for a particular plantation would be to carry out actual manurial experiments in the plantation itself. Even the simplest of such trials interferes with the normal routine of the commercial plantation. Moreover, in the majority of plantations soil variation, the interplanting of different varieties and variation from tree to tree of the same variety make such manurial experiments impossible; in such plantations it is often impossible to find even six pairs of similar trees sufficiently close together to assume with safety that but for the application of manure to the one set of six trees they would have grown similarly to the unmanured, or differently manured set.

(*d*) *By Tree Injection.* In such a plantation, however, a number of trees may usually be found with three or more branches which are sufficiently alike to be used for experimental purposes if it were possible to introduce a different manure or mixture of manures each into a different branch. This can now be done.

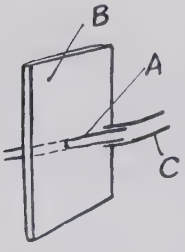


FIG. 1.

Method (1). The material to be injected is dissolved in sufficient water to make a solution of roughly $\frac{1}{4}$ per cent. strength (1 lb. per 40 gallons). This strength has been found safe for all the artificial manures tried; some can be used stronger without ill effect. The solution is held in some convenient vessel placed in the crotch of the tree or supported in some other way above the level of the injection point. At the injection point a hole is drilled through the stem of the tree with a $\frac{1}{4}$ in., or smaller, bit or drill. The small glass tube A (see Figs. 1 and 2) is placed with one end in the hole so that the collar of sponge rubber B fits against the bark. A similar piece of sponge rubber D is placed over the other end of the hole; and the two are bound into position by winding strips E, cut from old motor inner tubes, round the tree trunk. In this way a water-tight joint is made with the hole. If the bark is rough it must be smoothed with a large knife before placing the rubber in position. The tube A is connected with the liquid by means of rubber tubing C. This can be fitted to a hole near the bottom of the vessel or it may be just hung over the edge with its end on the bottom of the vessel and the liquid syphoned out. The liquid should be run in to fill

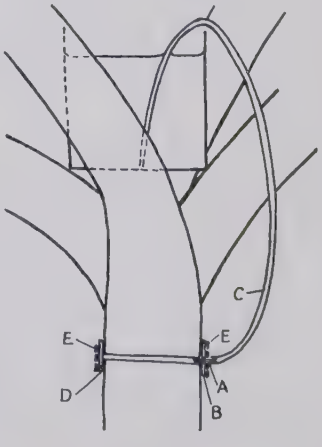


FIG. 2.

the hole in the trunk before the binding is finished so that the air can escape between the pad and the tree; as soon as liquid comes out the binding is finished off. With the apparatus ready, after the hole is bored, the remaining adjustments are completed in a minute or two. The whole operation, therefore, is not a lengthy one. The apparatus is cheap the vessels to hold the liquid being the most expensive part, unless suitable ones happen to be available; the tubing and sponge rubber would cost about 1s. Many trees can, therefore, be treated one after the other and be allowed to take up liquid at the same time. Enough manure is absorbed by these means in one to three days in Summer. Absorption in Winter is much slower and the results so far obtained suggest that larger amounts of manure can be injected without ill effect in Summer than in Winter.

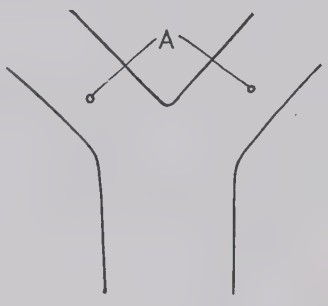


FIG. 3.

Position of Hole. The most convenient tree to take as an example is one with two main branches of roughly equal size. These branches are drilled just above the crotch, the holes (A in Fig. 3) being parallel to each other and just outside the centre of each branch. Injection through such holes results in each branch being practically uniformly "dosed" each with its own substance, which does not pass into the other branch. The liquids also travel downwards each into the roots which normally supply the branch into which it is injected. Trees with a larger number of main branches are treated in a similar manner.

Method (2). It is a convenience sometimes to compare experimentally a larger number of substances or mixtures on a single tree than is possible by the above method, in which each substance tested requires a single main branch comparable in size, etc. with the ones receiving the other substances; or it may be desirable to repeat the same comparison a number of times on the same tree. This may be done by cutting off an inch or so from the end of a current year's shoot and dipping it into the liquid to be absorbed. Such an injection results in every leaf on the current year's shoot receiving about an equal amount of substance. More distant leaves receive amounts which decrease as their distance from the cut end increases. No leaf further away than twice the length of the current year's wood receives any at all. This is a very convenient method for some purposes. By cutting off more of the shoot the length injected is increased but it is not advisable to remove more than half the current year's shoot.

Method (3). To inject branches larger than twigs but smaller than main branches, a hole is made in each about half-way between the branch tip and the point beyond which it is desired that none of the substance shall pass. This hole is "fed" from a bottle, tied to the branch just above the hole, through a rubber tube connected in the way already described.

Method (4). A whole tree may be injected through a hole drilled in the main stem, just below the crotch, so that each opening is between two branches. If the hole is immediately below a branch that branch gets more than its share of the substance. The hole should be so placed that the branches on either side of it are as nearly as possible equal in size. For large trees two such holes, roughly at right angles, are necessary.

Results of Injection. Elsewhere details will be given of experiments in which the injection of potassium nitrate into a large tree resulted in a doubling of the extension

growth ; the foliage was larger and of a healthier dark green colour than in previous seasons.

Similar experiments on small trees carried out by Mr. L. A. Thomas of the Commonwealth Council for Scientific and Industrial Research, Australia, while he was working at this Station, have shown a smaller but quite definite increase in growth following injection of a mixture of potassium sulphate and ammonium phosphate.

Two experiments, one on rootstocks and one on separate twigs of a large tree, have shown that injection of sodium thiosulphate may sometimes control an attack of apple mildew. The same methods are being employed to study the problem further.

Conclusion.

The above facts are sufficient to show that tree injection may be used for a variety of experimental purposes. The results mentioned and others to be found in the literature of the subject encourage the hope that further work may enable manurial deficiencies to be recognized by simple and inexpensive injection experiments carried out in the plantation. The actual operation is now so simple that practical treatment of whole plantations could be undertaken if the results obtained showed a sufficient advantage compared with those resulting from application to the soil. Before this work was started numerous attempts, mainly inconclusive, had already been made by injection to remedy mineral deficiencies and cure fungus and insect disease ; it is hoped that the increased precision with which substances can now be injected into trees and their course of distribution predicted may make such experiments more conclusive.

The apparent inability of No. V apple rootstock to absorb sufficient potash from a normal soil has already been mentioned. The present position has been summarized by Hatton as follows : " Potential leaf-scorch areas are unexpectedly widespread, and so unfortunately has been that continental interloper—the Doucin Ameliore—the misnamed Improved Doucin (No. V). The poor performance resulting from this combination of soil conditions and rootstock is enough to ensure economic failure despite ameliorating treatment " (1). In such a case when other methods have failed injection might well be tried. The possibility of speeding up the response to potassic manures by injecting them instead of, or in addition to, applying them to the soil will be tested. If many of the twenty-odd elements which occur in apple trees are of importance the manurial application of some of them to trees may well present even greater difficulties than potash.

The aim of this note has been to give briefly the present position and the general aims of this line of work. Some of these were dealt with at greater length in a contribution to a general discussion entitled " Physiological Disorders of Glasshouse Crops and Fruit Trees " (4) ; experiments establishing the general principles of tree injection form the subject of a paper to be published shortly ; joint work with Mr. L. A. Thomas, which has shown how all the damage which sometimes results from injection can be avoided, is also nearly ready for publication. Key references to the bulky literature of the subject will be found in these papers.

Summary.

1. Simple methods are described for injecting substances in solution into trees.

2. A whole tree may be injected uniformly with a single substance; each main branch with its own roots may be injected independently with a different substance or mixture ; and smaller branches, down to current year's shoots, may be injected each with its own substance without any reaching the roots.

3. Effects of injection on growth and disease so far obtained are mentioned.

4. Possible applications of the method for experimental and practical purposes are indicated.

References.

(1) Hatton, R. G. "Some Important Considerations in Modern Commercial Fruit Planting." Journ. Hort. Soc., 1934, LIX, 18-36.

(2) Roach, W. A. "The Chemistry of the Rootstock-scion Effect. I. The Elements absorbed from the soil. A Progress Report." E. Malling Res. Sta. Ann. Rep., for 1928-30. II. Supplement, 101-4.

(3) ——— "The Chemistry of the Rootstock-scion Effect. II. Methods for testing the Effects of Substances in solution on Fruit Trees. A Progress Report." *Ibid.*, 105-10.

(4) ——— "Injection for the Diagnosis and Cure of Physiological Disorders of Fruit Trees." Ann. App. Biol., 1934, XXI.

(5) Wallace, T. "Some Effects of Deficiencies of Essential Elements on Fruit Trees." Ann. App. Biol., 1930, XVII, 649-57.

(6) ——— "Some Physiological Disorders of Fruit Trees." Ann. App. Biol., 1934, XXI.

MYCOLOGY AND BACTERIOLOGY

NOTES ON PLANT DISEASES IN 1933*

By H. WORMALD

Diseases Not Caused by Parasites.

The year 1933 was characterized by the number of fruit troubles not due to parasites but brought about, directly or indirectly, by abnormal meteorological conditions.

In the third week of April (Easter Week) severe late frosts caused the destruction of many flowers of Morello cherries, black currants and raspberries. The earlier flowers of strawberries showed " black eye ", indicating that such flowers could not develop into fruit, and it was observed that wild strawberries in the woods were similarly affected. The severity of the frost was also shown by the wilting of the young foliage on chestnut stools in neighbouring copses, while early potatoes, too, were cut back. On apple trees the effect was seen in " frost blistering " of the foliage, and during the first week of May apple leaves showing this blistering were received from Horsham (Sussex) and Farnham (Surrey) ; in such cases the epidermis of the leaf separates from the rest of the tissues and becomes raised as blisters, ridges and puckers. Later the effect of the frost was seen on the fruit, that developed with a pronounced russeting round the eye, a characteristic feature of frost damage on apples.

Hailstorms occurred in various parts of Kent and Sussex about the middle of June (at East Malling, 19th June) causing, in some localities, severe injury to fruit ; apples and loganberry fruits were pitted, cherries and plums were bruised, leaves were lacerated (almost to shreds in some cases) on apple trees and strawberry plants, and on hops leaders were broken. The bruised fruit soon became infected with Brown Rot (*Sclerotinia fructigena*) and, in spite of the dry Summer, Brown Rot during 1933, particularly on apples and plums, was more prevalent than in 1932.

During the last week of June and the first week of July apples were received that showed deep cracks accompanied by Brown Rot infection, the fungus entering at the cracks. From the beginning of May to the middle of June, hardly any rain fell but there were heavy showers during the second half of June. Heavy rain following a period of drought almost invariably produces cracking of fruit ; the check in development during the dry period produces a hardening of the skin which, in consequence, ruptures when a copious supply of water causes a rapid development of the internal tissues. The only precaution the grower can take against such abnormal conditions is to cultivate thoroughly during the dry period in order to encourage steady growth.

Damage to fruit as a result of measures directed against pests or diseases came to our notice from various localities. Plum and pear leaves received from Sussex in May showed scorching probably caused by lime-sulphur. On the plum foliage the damage was aggravated by aphis damage. The pear leaves were from the variety Doyenne du Comice, one that is very susceptible to lime-sulphur injury; on this variety lime-sulphur should not be used stronger than 1 in 100.

Apples with dark purple spots were sent to us from two localities about the end of June, the varieties affected were Cox's Orange Pippin, Bramley's Seedling, Lord Derby,

* Republished by courtesy of the *Fruit Grower*.

Newton Wonder and Mr. Gladstone. In both cases the trees had been dusted with "lime-copper powder"; without doubt this was the cause of the damage, as we have seen similar spotting following the application of copper-containing dusts in other years.

Functional diseases, such as cork, bitter-pit and "glassiness" (or water-core) were again common. The prevalence of bitter-pit and similar spotting in the store is probably a result of the unusually dry Summer.

Diseases Caused by Parasitic Organisms.

Far less rain fell during the Spring and Summer of 1933 than in 1932, and this was reflected in the degree of attack by various fungous parasites; certain diseases were less severe than in the previous year, others more pronounced. Apple and Pear Scab, Brown Rot Blossom Wilt and Sooty Blotch were all less prevalent than during 1932. On the other hand, Fruit Brown Rot was more severe than usual, but there were certain conditions other than moisture that were factors in inducing a high degree of fruit infection; these factors are discussed below under Brown Rot Diseases. Certain rusts were very conspicuous and widespread, e.g. Plum Rust and Snapdragon Rust; the dry Summer would appear to have favoured these diseases.

Brown Rot Diseases.

Blossom Wilt was far less intense in 1933 than in 1932, when great destruction, particularly of apple blossom was reported. In contrast to 1932, only two cases of Apple Blossom Wilt came to our notice, one from Kent and one from Surrey. In one instance (on Lord Derby, a very susceptible variety) seven infected trusses were found in close proximity to an old dead spur that had been overlooked during the pruning operations, thus showing how the disease may accumulate from year to year if infected spurs are not pruned out, even in a year when the conditions are not very favourable for the fungus.

Brown Rot of fruit (*Sclerotinia fructigena*) on the other hand, was particularly severe during 1933. This was a result of unfavourable weather conditions early in the season, conditions that produced mechanical and physiological injuries that ruptured the skin and allowed the fungus to enter. As noted above, cracking (due to wet weather following drought) and bruising by hail, accounted for wounds which encouraged infection. This severe early infection allowed the fungus to get such a hold that, in spite of the dry Summer, the rotting continued on apples, pears, quinces and plums and produced considerable loss in the maturing fruit.

The severity of Brown Rot infection following the hail damage was clearly shown by observations made in August on a plot of fifty-four Stirling Castle apple trees at East Malling.* The fruit on these trees was badly damaged by hail and where the skin was broken, Brown Rot entered in very many instances. Only three trees were free from Brown Rot, three others had from one to three apples showing rot that apparently had no connection with hail injury. On all the rest one or more apples were infected at hail wounds. On one tree as many as twenty-two apples were infected at hail wounds and three others were infected from being in contact with infected fruit. Infection was also seen to occur at wounds caused by capsids, codling moth, and sawfly.

Brown Rot infection of apples picked without stalks was again noticed (on the variety Grenadier); this form of infection seems to be more common than is generally recognized, and attention has again been called to it in a recent note.†

* I am indebted to Miss B. Mounsey-Wood for taking these records.

† See *Journ. Min. Agric.*, October, 1933.

Apricots received from Jersey in July showed pitting accompanied by rotting. The cause of the pitting was not determined, but the injuries allowed *Sclerotinia fructigena* to enter and the fruit became destroyed by Brown Rot.

Crown Gall.

Tumours which appear to be of the crown-gall type have been received from various localities; the plants on which they occurred were loganberry, mangold, vegetable marrow and dahlia. Isolation plates have been prepared from these galls and bacteria have been isolated from them; some of these organisms show resemblance to the crown gall bacterium (*Bacterium tumefaciens*) in certain characters and are being retained for further study. An enquiry has also been received from Cheshire regarding crown-gall in raspberries; the correspondent writes, "It appears to be on the increase in one or two parts of the county, causing difficulty to both nurserymen and growers—one grower is fast losing his stock of Lloyd George." Large galls on loganberries were received from two localities and on this host again the disease would appear to cause sufficient damage to attract notice.

Sooty Blotch (*Gloeodes pomigena*).

This disease was less severe than in 1932 and its intensity evidently varies with the weather conditions; it is usually most abundant in wet seasons. A few apples showing blotch were found at East Malling and a specimen was received from Hampshire. On Warwickshire Drooper plums it was again very noticeable, the dull blotchy appearance of the picked fruit being a conspicuous feature; it would appear that this variety is particularly susceptible to Sooty Blotch.

Armillaria Root Rot.

Root rot of fruit trees caused by *Armillaria mellea*, the Honey Fungus, continues to be troublesome in some parts of the country and several enquiries have been made about it during the year. One grower, who had had three Bramley's Seedling apple trees attacked, brought in, for identification, black strands which he had found round an oak gate-post. The strands proved to be the rhizomorphs of *Armillaria mellea* and possibly if the post had been left the fungus would have made use of it as a source of nourishment and its rhizomorphs would have grown out to trees in the vicinity and infected them.

Grey Mould on Morello Cherry.

During May a Morello twig was brought in bearing a young shoot girdled by a lesion about $\frac{1}{2}$ in. long; in the middle of the lesion was a node with a withered leaf bearing the fructifications of *Botrytis cinerea*. On a Morello plot at East Malling about one infected leaf per tree was found, but not all had caused shoot lesions when examined.

In order to ascertain whether the fungus on the leaf had actually penetrated into the shoot, the surface of the discoloured portion of the shoot was cleansed with cotton wool soaked in alcohol; sections were then cut and placed on a culture plate. Within a fortnight the plate was covered with a pure culture of *Botrytis cinerea*, conidiophores and sclerotia being present. It seemed evident, therefore, that the fungus had first infected the leaf and had then extended into the shoot.

There is no reason to suppose that this type of infection is likely to prove troublesome on Morellos, but when it affects the shoots in this way it causes a certain amount of

" dying-back ". *Botrytis cinerea*, the Grey Mould fungus, is so widespread and attacks so many kinds of plants under conditions favourable for it, that it is advisable to cut off and burn all parts found affected with it, on any plant.

Branch Blister.

This disease on apple trees sometimes attracts the attention of growers for when it is severe it resembles, superficially, a very serious attack of apple scab on the " wood ". Specimens showing this condition have been received from one locality in Sussex (twigs affected) and two in Essex where stems of young trees were very severely blistered. Although known as " Branch Blister ", it may occur on young stems as well as branches. The constant association of the fungus *Coniothecium chomatosporum* with this condition on apple trees suggests that the fungus is the cause of the trouble, but experiments carried out at East Malling have hitherto failed to establish its parasitism and it is suspected that soil conditions and the stocks on which the trees are worked are factors that must be taken into account.

Raspberry and Loganberry Diseases.

Raspberry Mosaic continues to be the most serious trouble in raspberries and many enquiries have been received concerning it. Now that plantations of disease-free canes are being raised, it is possible for the grower to start with clean plants and so ensure a longer period of bearing for his plantation. An account of this disease in relation to raspberry cultivation in Britain has been published by R. V. Harris.*

Fungous diseases of the raspberry, viz. Spur Blight (*Didymella applanata*), Cane Blight (*Leptosphaeria coniothyrium*), Cane Spot (*Plectodiscella veneta*) and Blue Stripe Wilt (*Verticillium dahliae*) were all observed during the year, but, on the whole, they were not very prevalent, probably owing to the dry conditions during Spring and Summer. Lloyd George canes with severe Spur Blight were brought in by a grower from a plantation near Sevenoaks. Specimens of Pyne's Royal received from Maidstone in July showed Mosaic and Cane Spot on the young canes and Cane Blight on the old (fruiting) canes.

Mildew (*Sphaerotheca humuli*) is not usually serious on raspberries but in one case brought to my notice, canes were bearing fruit, the great majority of which were infected and quite worthless, many being more or less deformed.

Last year R. V. Harris recorded a fruit spot of raspberries caused by the Cane Spot fungus. In 1933 similar spotting, the same fungus being present on the spots, was found on loganberry fruits.† On logans, therefore, as on raspberries, this fungus causes spotting of canes, leaves and fruit.

Strawberry Diseases.

Yellow-Edge. This disease, now known to be caused by a virus,‡ is probably fairly generally distributed in our strawberry growing areas. In May, June and July plants showing the typical symptoms were seen in various localities in Kent, and specimens were received from Sussex and Surrey. Affected plants were also seen in strawberry plantations in Hampshire and in Scotland.§

* *Journ. Pom. and Hort. Sci.*, 1933, XI, pp. 237-55.
† Observations made by Miss J. B. Hamond at East Malling.
‡ Harris, R. V. The Strawberry " Yellow-Edge " Disease. *Journ. Pom. and Hort. Sci.*, 1933, XI, pp. 56-76.
§ Observations made by Dr. G. H. Berkeley and Mr. N. H. Grubb.

On our identifying the disease on plants sent in from Surrey, the grower wrote : " This is the disease I am sure that has ruined all my plantations of the last three years."

Root Rot. A disease of strawberries affecting directly the roots and producing a dwarfing of the plants or killing them outright appears to be widespread. It is being specially studied at East Malling by Dr. G. H. Berkeley (of St. Catharines, Ontario) who has found that the root rot symptoms on the strawberry in this country are very similar to those that he has observed in Canada.

OTHER DISEASES.

In addition to the diseases described above, the following are worthy of mention :

Blackberry Rust. Leaves of the cut-leaved blackberry (*Rubus laciniatus*) received from Essex showed severe infection by *Phragmidium violaceum*.

Gooseberry Cluster Cup Rust (*Puccinia pringsheimiana*) was found on gooseberries sent in from Bedford and two localities in Sussex. It is usually found on the young berries causing deformation and preventing their full development : infected Leveller gooseberries received towards the end of June, however, were large, almost fully grown, and nearly ripe though disfigured with this disease.

Vine Mildew. Bunches of grapes received from Sussex in August showed all the grapes mildewed and some cracking.

Hop Wilt (*Verticillium albo-atrum*). This disease first found at Penshurst (in 1924) and later at Matfield, appeared in a hop garden near Paddock Wood in 1933. The fungus associated with this outbreak was found to be *Verticillium albo-atrum*, the same fungus found to be the parasite in the earlier cases of hop wilt.

Tomato Diseases. Several enquiries, accompanied by specimens, were made concerning the tomato diseases Spotted Wilt (a virus disease), Blotchy Ripening and Greenback (non-parasitic). Spotted Wilt was recorded in Australia in 1915. In England it was first noticed on tomatoes in 1931 and now it appears to be widespread. The difficulty of controlling it is enhanced by the fact that the disease is transmitted by two species of Thrips and that it infects also a number of ornamental plants.

Beetroot Rot (*Phoma betae*). Beetroots from an East Malling garden showed various degrees of rotting : about half were affected and some were completely useless when taken from storage in December, although when put into store they were apparently quite healthy. The fungus *Phoma betae*, found on the rotting areas, was probably the cause of the trouble ; it is known to attack beetroots and mangolds.

Snapdragon Rust (*Puccinia antirrhini*). This disease was seen in a number of gardens in and around East Malling and Maidstone from August to October. It had not been recorded for this country before 1933.* Previously it was known only in America and in the Bermudas. During the Summer it was noted by other observers in various counties and it appears to have been widespread in this country.

Sweet William Rust (*Puccinia lychnidearum*). A specimen with leaves and stem badly infected was received from Hawkhurst.

Leaf Blotch of Shasta Daisy. In September, leaves showing this disease were received from North Devon : this is another locality for this disease in Britain ; it had previously been found in Kent and Hampshire, and in Wales.

Lilac Bacteriosis. This disease was found at Marlborough in 1932. In 1933 it appeared in two other localities, one in Wiltshire, the other in Surrey.

* D. E. Green, of Wisley, was the first to record the disease for this country.

BACTERIAL DISEASES OF STONE FRUIT TREES IN BRITAIN

V. SOME FIELD OBSERVATIONS AND EXPERIMENTS ON PLUM BACTERIAL CANKER

By H. WORMALD

It has been shown in previous articles* that "Die-back" in plum trees is largely due to Bacterial Canker caused by the organism *Pseudomonas mori-prunorum*. The habits of this organism have been studied and, from the information so obtained, it is considered likely that control of the disease can be effected by the application of a bactericide at certain periods of the year, if the operations are carried out with reference to the behaviour of the organism. Thus since it is known that the bacterium infects the leaves during Spring and Summer, spraying the foliage during Summer should check the leaf-spot phase of the disease, while a thorough drenching of the stems and branches about the time of leaf-fall should prevent stem infection. Bordeaux mixture is recommended, for copper sulphate at fairly low concentrations has been found to be toxic towards the canker-causing bacterium. These measures are tentatively advocated and, although direct experimental proof of their efficacy is at present lacking, some growers have tried them and have reported good results. However, until such measures have been proved experimentally to be reliable, it was thought advisable to study other methods of reducing the ravages of this disease. Possible ways of attacking the problem were sought along the following lines: (1) *orchard practice*, particularly with reference to pruning or cutting back at those periods of the year when the trees are least liable to become infected through wounds; (2) *the use of resistant stems*; (3) *soil conditions*.

Orchard Practice.

Experiments have shown that stems of plum trees are more predisposed to infection during Autumn and Winter than in Spring and Summer. Attempts to infect stems during the months of May, June, July and August failed, so that in Summer the stems are definitely resistant, while the months when infection was most successful were October, November and December. It is believed therefore that the stems become infected with bacteria washed down from the bacterial spots on the leaves shortly before leaf-fall. The possibility that infected leaves, falling to the ground, may cause the soil to be a source of infection has been considered, but inoculation experiments carried out with soil taken from around the base of a diseased tree have yielded negative results, and at present there is no evidence that infection comes from the soil.

That plum trees are highly predisposed to bacterial canker in Autumn is shown not only by direct inoculations but also by field observations on naturally infected trees. On one plot at East Malling plum trees had been interplanted with pear trees. By 1930 the latter had reached such a size that, in order to permit of their better development,

* The previous articles of this series have appeared in the Annual Report for 1926-7 (II Supplement), 122-127; *Ann. Appl. Biol.* 17 (1930), 725-44; *Journ. Pom. and Hort. Sci.*, 9 (1931), 239-56; *Trans. Brit. Mycol. Soc.*, 17 (1932), 157-69.

it was decided to cut back the plum trees, and many branches were cut out in October that year. The precaution was taken of covering the pruning wounds with lead paint. During the following Summer it was observed that many plum branches on this plot bore yellowish or withered foliage. An examination showed that at the base of each affected branch there was a bacterial canker and invariably towards the centre of the cankered area there was a pruning cut. It was obvious that infection had arisen at the pruning cuts in spite of the protective paint.

The varieties affected were Victoria, Czar, Giant Prune, Purple Egg, Pershore Egg, Belle de Louvaine and Denniston's Gage. The Victorias were by far the worst. In one row of eleven trees of this variety seven were affected. On one tree three large branches showed the foliage symptoms characteristic of trees with bacterial canker, and at the base of each there was a canker, extending round a painted pruning cut. Nearly one half of another tree was affected ; one large branch was dead, and the canker (again starting at a pruning cut) had entered into the stem itself ; two other branches were also dead and each had a canker, round a pruning cut, at its base.

On another plot fourteen trees (ten Victoria, two Czar, one Giant Prune and one Bastard Victoria) showed similar infection with one or two lesions on each tree, seventeen cankers in all. Of these lesions thirteen had started at pruning wounds, one where a twig had been broken off, another at a torn wound ; the other two could not be traced to any definite mechanical injury. The damage caused by the cankers was worst where large branches had been cut away from near the crotch, for in such cases when a canker arises it affects the main stem. Three of the trees showed these crotch cankers ; one was killed outright and on each of the others about half the tree was killed, on the side bearing the canker.

With the exception of two doubtful cases, therefore, all these cankers arose at definite injuries, either pruning cuts or torn wounds. Again, in inoculation experiments the cankers have arisen at, and extended from, the points of inoculation only. These observations show that, on branches and stems, the canker bacterium is mostly, if not exclusively, a wound parasite, entering through mechanical injuries made deliberately (through ignorance of the consequences) or arising fortuitously from wind damage, heavy bearing, or careless picking resulting in broken branches. When cutting back, pruning, or de-feathering is necessary, it should be carried out before October or postponed until late Winter.

The Use of Resistant Stems.

Field observations on plum plots at East Malling and in commercial plantations, show that certain varieties of plums are more susceptible than others to bacterial canker. Thus Victoria and Czar have suffered considerable losses on the trial plots at East Malling, and complaints from growers have been chiefly with reference to these varieties. Other varieties such as Purple Egg and Denniston's Gage are rarely severely affected and Utility appears to be definitely resistant.

When a branch only is cankered, the damage caused may be insignificant unless a main limb is affected, but when the crotch becomes cankered one or more main limbs may be involved and the result is more serious. When stem and crotch cankers encircle a tree that tree is doomed. The question arises, therefore, whether it may not be possible to produce resistant stems on which other varieties, that are susceptible to bacterial canker but more valuable commercially, may be worked.

In order to obtain some information on this point inoculations have been carried out on young nursery trees using three varieties as stems, and field observations have been

taken on older trees where the scion has been Victoria (so that the crotch and branches were this variety) while the stem has been either Victoria or derived from the stock.

Experiment 1. Inoculations were carried out on plum trees of which the crotch and branches were Victoria but the stems were one of three varieties :

(*a*) Victoria budded high on Brussels. Stem Brussels.
(*b*) Victoria budded low on Brussels. Stem Victoria.
(*c*) Victoria over Denniston's Gage on Brussels. Stem Denniston's Gage.

Twelve trees of each category were inoculated on the stems on 8th November and examined the next Summer, with the following results :

Variety of Stem.	Range in length of cankers.	Average length of cankers.	No. of cankers which girdled the stem.
(*a*) Brussels	3 to 12 cm.	7·3 cm.	None
(*b*) Victoria	5 to 45 cm.	17·2 cm.	Two
(*c*) Denniston's Gage	12 to 55 cm.	32·0 cm.	Two

Experiment 2. Trees of two categories :

(*a*) Victoria worked low on Brussels. Stem Victoria. Nine trees.
(*b*) Denniston's Gage worked low on Brussels. Stem Denniston's Gage. Seven trees.

Variety of Stem.	Range in length of cankers.	Average length of cankers.	No. of cankers which girdled the stem.
(*a*) Victoria	4 to 45 cm.	24·0 cm.	Four
(*b*) Denniston's Gage	10 to 27 cm.	15·9 cm.	None

From these experiments it appears that Victoria and Denniston's Gage stems are both definitely susceptible when artificially inoculated with the bacterial canker organism while Brussels is more resistant though not immune.

Why Denniston's Gage is apparently almost, if not quite, as susceptible as Victoria (in Experiment 1 the cankers were longer on Denniston's Gage than on Victoria) when artificially inoculated, while if left to natural infection in the plantation it seems to be far more resistant, is not known, with certainty, but it probably bears some relation to the degree of leaf infection. Of the commercially grown varieties Victoria is perhaps the most susceptible to leaf infection ; young trees of this variety have been seen with almost every leaf riddled with " shot holes " following severe bacterial leaf spot. If, as is thought to be the case, infection of the stem occurs in the Autumn from bacteria washed down from the leaves, those trees with heavily infected leaves are more liable to stem infection than trees with slight leaf infection.

On the other hand there are varieties which appear to be definitely resistant to direct stem infection (compared with such very susceptible varieties as Victoria and Czar) as shown by Brussels in Experiment 1, and by Common Plum and Myrobolan B, as indicated by the field observations recorded below, even when they carry branches and foliage of Victoria.

Field Observations.

On one of the plots at East Malling, there are three rows of Victoria plum trees worked on the two stocks Common Plum and Myrobolan B ; some of the trees were

worked high so that the greater part of the stem was the same variety as the rootstock, only the upper part of the stem with the crotch and branches being Victoria ; others were worked low so that the stem from ground level upwards was Victoria. They were planted as one- or two-year-old trees in March, 1927.

During the Summer of 1928 six of the trees showed bacterial canker ; four of these became girdled and died. All the six trees were worked low and no bacterial cankers at all were seen at that time on the trees worked high. In 1930 there was a further outbreak of the disease on the plot ; the affected trees were mostly low-worked, but a few were high-worked.

The trees on which bacterial canker was observed during those two seasons are recorded in the table. When a stem was girdled (marked +), the tree did not recover and it either died during the Summer or it was dug up with yellowish foliage before actually withering. When a stem was only partly girdled (marked −) the tree recovered. The first six trees are those noted in 1928, the rest were recorded in 1930. Attention is drawn to the situation of the cankers on the high-worked stems by italics.

INCIDENCE OF BACTERIAL CANKER ON VICTORIA PLUM TREES WORKED HIGH OR LOW ON MYROBOLAN B (M) OR COMMON PLUM (CP).

Row and No. of Tree.	Worked.	Girdled (+) or not (—).	Remarks on size and situation of canker on stem.
1/11	low on M	+	1 ft. long from crotch down.
1/15	,, ,, M	+	in upper half of stem.
1/31 (*a*)	,, ,, M	+	,, lower ,, ,, ,,
2/5	,, ,, M	+	,, upper ,, ,, ,,
2/6	,, ,, CP	—	from ground level 18 ins. up. ¾ girdling.
2/29	,, ,, CP	—	from band nearly to ground level. ½ girdling.
1/7	,, ,, M	+	from crotch to ground level.
1/10	,, ,, CP	—	from ground level upwards for 6 ins.
1/14	*high* ,, CP	+	*from crotch downwards for about 1 ft. extending a few inches into stock.*
1/21	low ,, M	+	from crotch to ground level.
1/23	,, ,, M	—	from ground level upwards for 18 ins.
1/31 (*b*)	,, ,, M	+	from crotch to ground level.
1/32	,, ,, CP	—	1 ft. long in middle of stem. ½ girdling.
1/34	,, ,, CP	+	from crotch to middle of stem.
2/4	*high* ,, CP	+	*from crotch downwards to about 18 ins. above ground level.*
2/12	low ,, CP	—	from ground level upwards for 1 ft.
2/14	*high* ,, M	+	*from crotch downwards for 1 ft. extending a few inches into stock.*
2/18	low ,, M	+	from crotch to middle of stem.
2/24	,, ,, CP	+	9 inches long in upper half of stem.
2/30	*high* ,, M	+	*from crotch to middle of stem, including about 18 ins. of the stock.*
3/2	low ,, CP	+	about 2 ft. 6 ins. long from just above middle of stem downwards.
3/8	*high* ,, CP	+	*from crotch downwards for about 1 ft. 6 ins. extending about 12 ins. into stock.*
3/15	low ,, M	+	from ground level upwards for 2 ft.
3/16	,, ,, CP	+	about 3 ft. long from just above middle of stem to 6 ins. above ground level.
3/17	*high* ,, M	+	*from crotch to middle of stem including 18 ins. of the stock.*
3/21	low ,, M	+	2 ft. long in middle region of stem.
3/25	,, ,, CP	+	1 ft. long from crotch downwards.
3/33	,, ,, CP	+	about 18 ins. long in middle region of stem.

The plot comprised eighty-five trees in all, thirty-four worked high and fifty-one worked low. One of the infected trees 1/31 (*a*), was taken out in 1928, and replaced by another planted in the same spot. The replant, 1/31 (*b*) went down with bacterial canker in 1930. Including this in the number above and so taking the number of trees worked low as fifty-two, a comparison of the degree of infection according to whether the stem was the scion Victoria or one of the two stocks is here tabulated.

	No. of trees.	No. of trees cankered.	Percentage of trees cankered.	No. of trees killed.	Percentage of trees killed.
Worked high ..	34	6	18	6	18
,, low ..	52	22	42	16	31

These results lead to the following conclusions:

(1) Infection on the high-worked trees is much less than on the low-worked trees.

(2) On the high-worked trees the cankers were all in the upper part of the stem and involved the crotch. In these cases it appeared highly probable that infection had started in the scion and had extended downwards into the stock.

(3) As there was no instance where the stock stem alone became infected, it would seem that the two stocks used have some inherent resistance to direct infection.

(4) In low-worked trees (stems Victoria) infection occurred at any part of the stem from crotch to ground level.

(5) Of the twenty-eight trees which became cankered fourteen were on Myrobolan B and fourteen on Common Plum, so there is no evidence that, of these two stocks, one is to be preferred to the other from the point of view of modifying the predisposition of Victoria to bacterial canker.

The general conclusion to be drawn is, that Victoria plum trees worked on Common Plum or Myrobolan B are less liable to be killed by bacterial canker when worked high (stem as stock) than when worked low (stem Victoria). This is probably simply because there is a shorter length of susceptible scion stem to become infected. If then the process is taken a step further and a resistant stock is used not only as stem-builder but as framework also, so that the crotch and primary branches are of the same variety as the stock, there should be still less chance of a tree being killed outright by bacterial canker. The scion branches would be separated from one another and if one became infected the canker would probably be confined to that branch, for it has been found that the cankers are not perennial and when individual branches are attacked the infection does not extend to other parts of the tree unless it happens to be at or near a fork or at the crotch, when other branches may become involved. Experiments to test the value of such a procedure are in progress. (See p. 106 of this Report.)

Soil Conditions.

In this preliminary experiment attention was chiefly directed towards the effect of potash, as it was thought that it might tend to harden up the tissues and render them more resistant.

The plot consisted of eight rows of young Victoria plum trees worked on two stocks, twenty-five trees in each row. The stocks, Brompton and Brussels, were planted in alternate rows in the Spring of 1928 and they were budded in July. The buds grew out the following year and during their period of growth the plots received the treatments as shown in the Table.

The trees were 1 ft. apart in the rows and the materials were spread as evenly as possible over an area extending to 1 ft. on each side of the row. The area of each row plot was therefore 50 sq. ft., and 4 ozs. per plot is approximately 2 cwt. per acre. The applications were made at this rate on 1st July and 14th August and again the following year on 27th February and 16th June.

In the Summer of 1930 a number of these trees showed bacterial canker and they were examined to ascertain whether the degree of infection bore any correlation with the stocks on which the trees were worked, with the vigour of the tree, or with the manurial treatment.

In all twenty-one trees went down with the disease. Of these eleven were on the Brompton stock and ten were on Brussels, so for these two stocks Victoria would appear to be as susceptible on one as on the other.

On plots 1 to 6 the trees showed considerable variation in vigour. On these plots there were seventeen infected trees of which eight were below the average vigour and nine were above the average, so that degree of vigour seems to have no effect on predisposition to bacterial canker.

With regard to manurial treatment, the distribution of the diseased trees is shown in the Table :

Row.	Stock.	Treatment.	No. of infected trees.	Total per treatment.
1	Brompton	Ammonium Sulphate 4 ozs.	2	3
2	Brussels	,, ,, ,,	1	
3	Brompton	Control : no treatment	4	5
4	Brussels	,, ,, ,,	1	
5	Brompton	Sulphate of Potash 4 ozs.	1	9
6	Brussels	,, ,, ,,	8	
7	Brompton	Guano +4 ozs. Sulphate of Potash	4	4
8	Brussels	Guano only	0	0

The figures are too low for any definite conclusion to be drawn regarding the relative effect of the different treatments, but it would seem that, under the conditions of the experiment, potash had not had any restraining influence on the predisposition of the trees, as more than half the infected trees were on the three plots that received potash, though possibly it was applied too late to be really effective even on such small trees. The applications made in February and June, 1931, would not be likely to affect the development of the cankers ; it was thought, however, that they might have some influence on the incidence of bacterial leaf spot, but as this phase of the disease was almost absent from the plots during the Summer, no conclusions could be drawn.

To test these points further a more elaborate experiment has been planned in which randomized plots are receiving different treatments and the fertilizers applied not only during the season when the buds grow out, but also during the preceding year.

Summary.

1. Pruning or cutting back plum trees in Autumn is to be avoided as bacterial canker infection may arise at the cut surfaces.

2. Inoculation experiments and field observations have shown that Victoria is subject to severe infection by the Canker bacterium when worked on any one of four

commonly employed stocks for plums, viz.: Brussels, Brompton, Common Plum and Myrobolan B.

3. The variety Denniston's Gage, that shows apparent resistance in the plantation, succumbed to artificial inoculation as readily as Victoria, while artificially induced cankers on Brussels stems were distinctly smaller than those on Victoria stems.

4. Victoria when worked high (stem as stock) on Myrobolan B or Common Plum had a lower percentage of trees killed by bacterial canker than when worked low (stem Victoria).

5. The possibility of employing a resistant variety as stem and framework for a more susceptible but more valuable variety is discussed.

6. On manurial plots, potash, applied to budded trees during the year the buds grew out, had no restraining effect on the incidence and development of bacterial canker on the maiden trees.

STRAWBERRY ROOT ROT

By G. H. BERKELEY

DURING the past five or six years considerable attention has been given to " root rots " of strawberry in America and elsewhere. In many localities in the United States of America and Canada " root rot " is a factor of great importance and is considered by many to be one of the fundamental causes of " failure " in strawberry cultivation. In Britain, however, very little attention has been given to " root rots " with the one exception of the studies made in Scotland on the so-called Lanarkshire disease.

The symptoms of root rot as generally understood in America are as follows: Affected plants lack vigour, the leaves and petioles are dwarfed, and the root system is greatly reduced. The leaves take on a brownish tint, and in time wilt and die prematurely. However these above ground symptoms are only suggestive, and the roots must be carefully examined before a definite diagnosis can be made. The roots of affected plants are noticeably lacking in fibre, and young main roots may be black and dead, or sharply defined black lesions may be apparent on an otherwise healthy looking root. The presence of these lesions is definite evidence of root rot (Fig. 2).

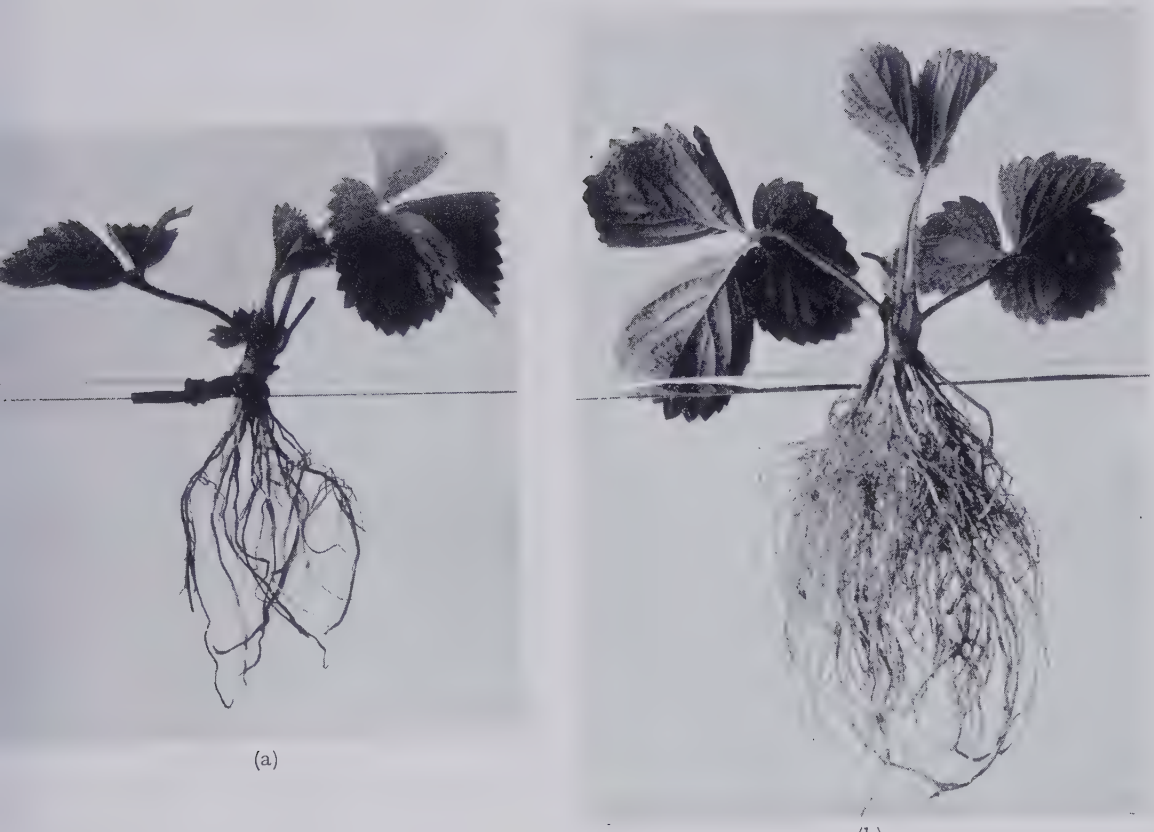
As a result of a preliminary survey of strawberry plantations in Sussex and Kent this past season, many plantations were observed in which numerous plants appeared to be stunted and unthrifty; their roots lacked fibre and showed the presence of distinct lesions similar to those described for " root rot " in Canada and the United States of America.

It appeared, therefore, as though " root rot " might be present in England, and accordingly preliminary experimental work was started to ascertain if this was the case.

In a preliminary inoculation test strawberry plants grown in sterilized soil were inoculated with an infusion obtained by macerating affected roots taken from plants showing root rot symptoms. Within a month definite lesions appeared on the roots of the inoculated plants, whereas the roots of the control plants remained perfectly healthy. By control plant is meant a plant grown in sterilized soil to which no infusion of roots was added. This experiment definitely indicates that there must have been something present in the affected roots which was able to attack the new root system as it developed (Fig. 1a.)

The second test was to ascertain if the soil from around diseased plants contained the disturbing factor. Accordingly soil was taken from a plantation where root rot was present and new runner plants were struck into sterilized and unsterilized soil from this source. After a month's time it was found that the root system in the unsterilized soil was considerably diseased with black lesions, and entire roots killed, whereas the roots in the sterilized soil were healthy. This test pointed out the additional fact that the causal factor was capable of existing in the soil.

The next step was to endeavour to find out just what it was that had produced these results, and so a large number of isolations were made from lesions on affected roots. These isolations gave rise to numerous fungi of which the most common were *Coniothyrium*, *Hainesia*, *Ramularia* and *Fusaria* in addition to such obvious saprophytes as *Penicillium* and *Mucor*. So far pure cultures of *Coniothyrium* sp. and *Ramularia* sp. have been inoculated into sterilized soil in which new runner plants were planted. In a



(a) (b)

FIG. 1.

Strawberry Root Rot. (*a*) Roots rotted as a result of adding "root maceration" from root-rot plants to sterilized soil in which above plant was grown. (*b*) Plant of same age and source in sterilized soil to which no "root maceration" was added. Note its healthy condition.

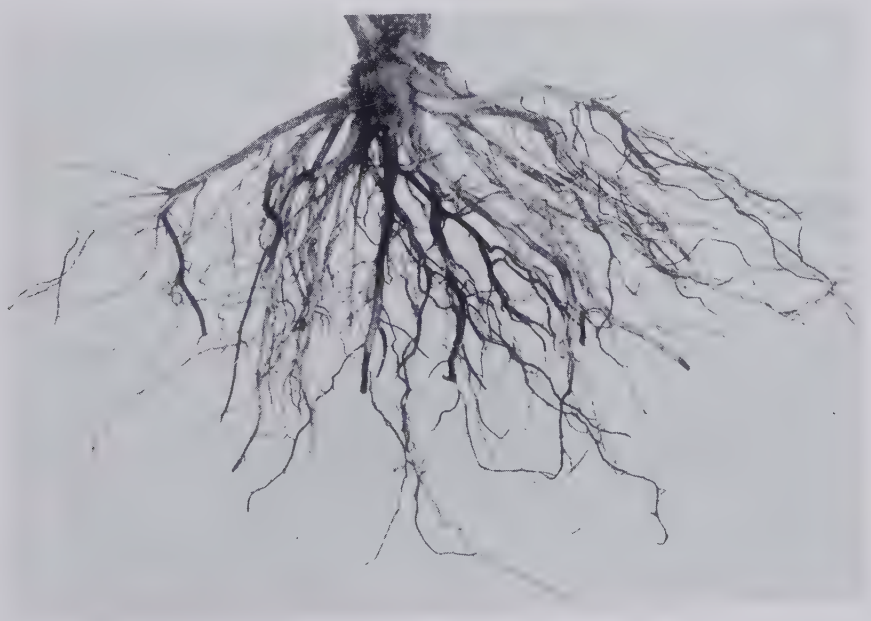


FIG. 2.

Strawberry Root Rot. Naturally affected root; note black roots (dead) and black "lesions" on otherwise healthy root. Note also lack of fine fibre.

month's time the *Coniothyrium* sp. had killed several of the roots and produced distinct lesions on others. It would appear, therefore, that *Coniothyrium* sp. is a cause of " root rot " in England. In the case of the *Ramularia* sp. some discoloration of the roots was noted, and a few lesions were apparent but this fungus did not appear to be as strong a parasite as the *Coniothyrium* sp.

The evidence adduced here strongly supports the contention that a definite " root rot " disease, or diseases, does occur in England. In this connection it is interesting to note that a *Coniothyrium* sp. and *Hainesia* sp. have been proved as the cause of a " root rot " in Michigan, while a *Ramularia* sp. has been shown to be the cause of a " root rot " in Ontario, Canada. It is particularly suggestive, therefore, that species of these three genera have already been isolated from diseased strawberry roots in Kent.

This whole subject of " root rot " in strawberries is receiving further study at East Malling and it is hoped that another year's work will at least enable us to evaluate with some degree of certainty its importance as a factor in the general degeneration of the strawberry.

Summary.

1. Field observations have shown that root rot is present in many strawberry plantations in Britain.

2. Inoculation experiments with maceration of diseased roots and with soil from an affected plot have shown that such roots and soil are infectious.

3. Various fungi have been isolated from lesions on roots of plants from plantations in the south of England.

4. The parasitism of a number of these fungi has been tested and two of them have produced lesions similar to those of naturally infected roots.

A FIELD SPRAYING TRIAL OF COMBINED FUNGICIDE-CONTACT INSECTICIDE SPRAYS IN 1933

A PROGRESS REPORT

By M. H. MOORE

Introductory.

The present demand for high-quality dessert apples and the desire of the home grower to produce them, is having widespread influence on spraying practice. Of the many problems that are encountered during the course of the spraying season, perhaps the greatest is that of being able to spray a large acreage of fruit efficiently in a very limited time. Although a satisfactory solution of this problem necessarily involves the suitability of the available spraying equipment, that aspect is not included in the scope of the present paper, which deals mainly with the biological issue. Up to the present, one important factor, among others, which limited the time that could be taken in " getting round " the plantation, has been the necessity for making separate applications of certain types of sprays—for example, a contact insecticide (nicotine) and a fungicide (Bordeaux mixture or lime-sulphur). Nicotine, to be most effective, requires the addition of a good wetting agent, and the spray is applied as a drench to kill by contact. The wetting agent in general use is soft soap, which, for chemical reasons, is unsuitable for use with Bordeaux mixture or with lime-sulphur. Moreover, the function of fungicides such as those mentioned is not to kill by contact, but to protect the tree from infection by fungi, and thus a " softer " spray is used to provide the necessary spray-film.

Hence, the biological issue involved would appear to be directed towards reduction in the number of spray-applications necessary for effective control of the pests and diseases normally met with in the commercial apple plantation. A fungicide, a contact insecticide and a stomach poison insecticide (lead arsenate) are the types of spray-fluids normally used in the routine spray-programme during the growing season. For many years, the combination of lime-sulphur and lead arsenate has been practised with success against Scab, Mildew and various caterpillars on apple, while nicotine and soft soap has been applied separately mainly to combat Aphis, Sawfly and Capsid. To meet the objections noted above to the use of combined contact insecticide-fungicide sprays, an effective wetter and spreader to replace soap would be necessary, while heavier applications of fungicides, perhaps of reduced strength, would need to be made to obtain the greatest benefit from the contact insecticide in the combined spray.

A FIELD SPRAYING TRIAL IN 1933.

With the foregoing considerations in view, a simple field trial on a large scale was carried out in 1933 on the plot of Cox's Orange Pippin trees formerly used for detailed tests of the value of different fungicides for Apple Scab-control. The layout of this plot, illustrated by a diagram, was fully described in a recent publication (7) in which

the present experiment was foreshadowed. It is intended to use this plot for a few years to determine the best complete commercial spray-programme for this important dessert variety. This scheme will probably entail changing the programme of sprays every year to meet new problems as they arise. Hence it is important that commercial conditions be preserved as much as possible by reducing the number of " control " trees to an essential minimum.

The immediate problem to be solved by this field spraying trial was whether by the use of sulphite lye (a by-product from a stage in the manufacture of cellulose from wood-pulp), the wetting and spreading properties of which have recently been investigated by Martin (2), lime-sulphur could be used in combination with nicotine or with derris with satisfactory fungicidal, insecticidal and phytocidal* results.

The plot of trees consisted of 158 Cox's Orange Pippins worked on various layered rootstocks and planted (at 12 ft. apart in rows 24 ft. apart) as " maidens " in 1921. Stirling Castle trees were interplanted in alternate rows, but they were not used in this experiment. The centre of the plot formed a dividing line for duplicate halves, so it was decided to compare a complete spray-programme on one half with another, different, one on the other. A few trees on No. VI stock were retained as unsprayed controls at the extreme ends of each half.

In deciding the identity of the two spray-programmes, opportunity was taken to test the respective merits of two pre-blossom lime-sulphur sprays against one. In former trials, certain results along these lines had been obtained on a smaller scale (7). Furthermore, it was resolved to omit lead arsenate altogether, and thus to determine whether this stomach poison was really necessary in a scheme which involved the liberal use of contact insecticides. It is well known that contact insecticides are effective against young caterpillars—indeed, it was the principle underlying Sawfly-control by the use of nicotine and soft soap.

The two programmes were :

West Half.†

1.	*At green-bud.*	Derris (2 lbs.) +sulphite lye (6 pints).
2.	*At pink-bud.*	Lime-sulphur (1-40) +Derris (2 lbs.) +sulphite lye (6 pints).
3.	*At petal-fall.*	Lime-sulphur (6 pints) +Derris (2 lbs.) +sulphite lye (6 pints).
4.	*Three weeks after* 3.	Lime-sulphur (1 gall.).

East Half.‡

1.	*At green-bud.*	Lime-sulphur (1-40) +nicotine (8 ozs.) +sulphite lye (6 pints).
2.	*At pink-bud.*	As at green-bud.
3.	*At petal-fall.*	Lime-sulphur (6 pints) +nicotine (8 ozs.) +sulphite lye (6 pints).
4.	*Three weeks after* 3.	Lime-sulphur (1 gall.).

Note.—All strengths except that for pre-blossom lime-sulphur are given for 100 galls. diluted spray. Sulphite lye liquid concentrate (60° Twaddell, 1·3 S.G.) was used as advised by Martin (2). Derris (rotenone content of 2·71 per cent.)§ was applied in collaboration with Mr. W. Steer of the Entomology Section.

Lime-sulphur was reduced in strength from 1-30 pre-blossom and 1-100 post-blossom when sulphite lye was used. It was considered advisable to do this to guard

* This term is now being used in reference to the effect of sprays on the tree (spray-injury).
† Hereinafter referred to as Plot D.
‡ Hereinafter referred to as Plot N.
§ Used at the rate of 2 lbs. per 100 galls. (0·2%), the diluted Derris spray thus had a rotenone content of 0·0054% (in terms of crude rotenone).

against possible spray-injury from the fungicide as a result of heavy applications of the combined spray.

The timing of the first post-blossom spray gave rise to an important point. Previous experiments on the same plot of trees had shown the necessity for applying protective sprays at certain periods to ensure good Scab-control. One of these periods was as soon after blossom as possible, i.e. at petal-fall. However, the eggs of the Apple Sawfly normally do not hatch until a week or so after this (when it was customary to make the separate application of nicotine and soft soap to kill the young larvae), so that, for nicotine (the effect of which does not last many hours) to be directly toxic to these larvae, petal-fall would be premature for application of the first post-blossom combined spray. But Derris was known to possess residual contact properties which might render the petal-fall spray effective against the larvae when they hatched several days later. Moreover, the value of a combined spray lay in its possibilities as a fungicide and an insecticide when applied at *petal-fall*, for it is unwise to delay the petal-fall application against Scab.

Hence, the respective combined sprays were applied at petal-fall (when only a thin sprinkling of petals remained on the trees), as for Scab-control, and not a week later, as for Sawfly-control.

Application of Sprays.

The trees were sprayed by the normal method used for routine spraying on the Research Station farm. A three-throw pump of 1,200 galls. per hour capacity at 400 lbs. pressure, driven by a 10 h.p. Lister petrol engine, was adjusted to develop about 300 lbs. pressure per sq. in., and supplied four men using 8 ft. lances and single nozzles fitted with No. 1 discs.

Green-bud Spray. Applied on 11th April after a long period of fine, hot weather and drought. The day was fine and warm with a light breeze from S.S.W. The trees were heavily sprayed. Derris with sulphite lye failed to wet and spread well on the foliage, but lime-sulphur with nicotine and sulphite lye gave excellent wetting and spreading. About 90 gallons of diluted spray (including wastage) were used on each plot (seventy-one trees on D ; seventy-two on N).

Pink-bud Spray. Applied on 21st April when the trees were in ideal condition,* and showing no signs of Scab-infection on either D or N. Indeed, ascospores were scarcely differentiated in the asci in last season's dead leaves at this period. In 1932, they had been dispersed long before pink-bud, and even prior to green-bud (7). Some conidia were present in pustules on the young shoots on last year's control trees, but any that may have been dispersed had caused no infection. A few days before 21st April the weather had become very cold and stormy. Conditions were not ideal for spraying, but it was considered unwise to delay the application. After a cloudy, dull morning, the sun shone brightly, while a gusty wind blew from N.N.E. The trees were heavily sprayed, and the wetting and spreading were highly satisfactory on all trees. Derris with sulphite lye was more nearly ideal in this respect when used with lime-sulphur than when used alone, as at green-bud. Nearly 100 gallons of diluted spray (including wastage) were used on seventy-one trees on Plot D. About 115 gallons were used on seventy-two trees on Plot N, where the trees are, on the whole, larger. Moreover, the wind had strengthened when Plot N was sprayed, and application in high wind always results in increase in the amount of spray used.

* As an illustration of seasonal variation, the pink-bud spray in 1932 was applied to the same trees on 18th May (7).

Petal-fall Spray. Applied on 15th May in excellent weather, fine and warm, with a light breeze from N.W. Marginal burning of the rosette leaves was observed on both D and N as a result of the pink-bud application. Records were not taken, but from general inspection there seemed to be more of this on D than on N. In neither case was the injury serious. The quantities of spray used at this application were similar to those given at pink-bud. The trees were heavily sprayed.

"Three-weeks" Spray. Applied on 7th June in very hot weather (which had already lasted about a week) with a fresh breeze from E. Lime-sulphur (1-100) only was used on both D and N, and the whole plot (D + N) was sprayed with slightly more than 300 gallons of diluted spray. The trees were more lightly sprayed on this occasion than at the other three periods, for there was no necessity, in the absence of a contact insecticide, to spray heavily. Nevertheless, more spray-fluid was used than formerly, doubtless on account of the greater amount and density of foliage. The trees were in very good condition—there was scarcely a sign of Scab except on controls, while it was evident that Aphis and Sawfly had been checked, particularly on Plot N.

Biological Observations and Weather Conditions.

Scab. This disease was not seen on any trees, sprayed or unsprayed, in this experiment until post-blossom. Soon after petal-fall, infections appeared on the leaves of control trees and then spread to the fruit. This infection developed slowly throughout the Summer. The long drought prevented the disease from assuming at any period epidemic intensity such as is seen in certain seasons. Comparison of the dates on which sprays have been applied in these experiments during the past three years brings to light a very remarkable fact. The period between green-bud and petal-fall in the three seasons was of similar duration, i.e. thirty-three days, but weather conditions greatly influenced the relative position of *pink-bud*. In 1933, the period from green-bud to pink-bud was ten days; in 1932, twenty days and in 1931, twelve days (7). In 1933, therefore, the blossom period was comparatively long. Very light rainfall occurred at East Malling in April (0·85 ins.),* mostly between the 23rd and 26th, just after the pink-bud application. In May, 2·21 ins. of rain fell, most of it on the 2nd, 6th and 23rd, with slight falls between. Scab-infection began in weather favourable for the fungus during the long blossom period, and first became visible on control trees soon after petal-fall. The pink-bud application afforded sufficient protection against this until petal-fall. From that time, rainfall was only light to moderate—August was very dry (0·69 in.)—until September, a month of unusually high precipitation (3·56 ins.) which occurred too late to influence Scab-infection on these Cox's. The weak post-blossom lime-sulphur sprays were thus considerably aided in their function of continuing initial protection afforded by the pink-bud application.

Sawfly. Observations made by G. L. Hey and W. Steer (see their report (1) on page 197) and the writer established that hatching of the eggs in Cox blossoms had not begun by the time the petal-fall application was made (15th May). Further observations showed that hatching had begun on 19th May on the interplanted Stirling trees but not on the Cox's. The petal-fall spray on Cox's was therefore applied at least four days before hatching commenced.

Since many eggs were present, however, *any effect the nicotine had must concern the unhatched egg*, for the toxic effect of this spray after application is only short-lived. It will be recalled that the possibility of affecting the unhatched egg of this Sawfly had

* The writer is indebted to Mr. H. C. Chapelow for these rainfall data.

already been envisaged (6), when infestation of Cox fruits was reduced by a petal-fall application of Bordeaux mixture with lead arsenate and of lime-sulphur with lead arsenate.

With Derris, ovicidal effect is most unlikely, so that any control given by this spray would be the result of contact action against subsequently-hatched larvae.

Spray-injury. Apart from the leaf-burn already mentioned, no damage was caused by any of the sprays.

Methods Used to Obtain Results.

The results concern only the fruit, dropped and picked. All dropped fruits were collected* from underneath each tree from fertilization to picking-time, and graded for Scab, Sawfly and Caterpillar (Winter Moth, etc.). The picked† fruits from each tree were all similarly graded. Scab-grading on picked fruits was effected, and subsequent calculations made, by use of the " category " method described elsewhere (3, 5), while apples attacked by Sawfly larvae or by caterpillar of Winter Moth, etc., were merely counted and recorded. The fruits were not graded for russeting as the amount present was negligible. Capsid-attack was not seen either on sprayed trees or on controls. Codlin Moth was not present in sufficient quantity to warrant the making of special records.

Results.

A complete table of results will be seen herewith. The treatment is referred to in the tabulated data simply as Plot D or Plot N—the spray-treatment on each plot is fully set out earlier in the paper.

The results in each case were worked out for each tree, then averaged for similarly-treated trees on the same rootstock.

The percentage Sawfly on picked fruits was negligible in comparison with that on dropped fruits. A separate column for this is not shown, therefore; the figure is included in the percentage attacked of total fruit " set ".

The percentage reduction due to spray-treatment of Scab, Sawfly and Caterpillar is based on the *average* attack on control trees on D and N together.

Discussion of Results.

The Crop. This was by far the largest ever produced by these trees. Although, naturally, as the trees mature, increase in cropping will be expected, there can be no doubt that, in the light of previous experience on this plot, great reduction in the number of control trees in 1933 was the primary factor governing this crop-increase. It has already been demonstrated (7) that trees sprayed for the first time after being unsprayed for years, showed a remarkable increase of crop in the first season of spraying.

It will be seen that, in general, more fruit (dropped and picked) was produced by trees on Plot N than by those on Plot D. It is remotely possible that the combination of lime-sulphur, Derris and sulphite lye used at pink-bud adversely affected to a small

* The writer is greatly indebted to Miss J. B. Hamond (East Malling Research Station) and to Mr. C. P. Quarrell (Reading University) for valuable assistance in this work.

† Large dropped fruits (windfalls) collected from mid-August till picking-time were recorded among the picked crop.

Stock.	Treatment (Plot N or D).	No. Trees.	Total No. fruit picked.	Total No. fruit dropped.	Total No. fruit produced ("set.")	AVERAGE PER TREE PER ROOTSTOCK. % Picked.	% Sawfly (all fruit).	% Caterpillar (all fruit).	% Caterpillar (picked fruit only).	% Scab (all fruit).	% Scab (picked fruit only).	Scab-equivalent (picked fruit only).
I	N	8	2,967	1,670	4,637	63·8	2·7	4·1	5·1	3·1	3·5	0·9
	D	8	2,573	1,715	4,288	60·7 } 62·25	14·0	2·6	3·3	1·8	2·3	0·6
II	N	8	3,400	3,304	6,704	51·4	5·2	4·8	5·5	3·2	3·2	0·8
	D	8	2,753	3,340	6,093	46·1 } 48·75	18·7	3·5	3·7	4·0	4·7	1·3
III	N	8	3,166	1,572	4,738	67·4	6·2	5·0	5·5	2·3	2·6	0·9
	D	8	2,089	1,617	3,706	57·1 } 62·25	10·3	4·5	4·1	1·8	2·1	0·7
IV	N	4	1,869	924	2,793	68·6	4·2	6·9	7·7	4·1	4·2	1·8
	D	4	2,097	1,000	3,097	68·6 } 68·60	15·7	7·4	7·6	3·8	4·5	1·3
V	N	8	3,576	3,319	6,895	53·5	4·4	3·3	4·4	3·4	3·9	1·0
	D	8	2,487	2,053	4,540	57·0 } 55·25	20·3	2·6	2·6	4·7	5·2	1·2
VI†	N	7	**873**	**1,127**	**2,000**	40·4	20·0	8·3 } **6·45**	7·3 } **6·25**	58·3 } **57·30**	79·2 } **88·55**	32·6 } **38·70**
	D	8	**1,164**	**2,166**	**3,330**	36·0 } **38·20**	40·3 } **30·15**	4·6 }	5·2 }	56·3 }	97·9 }	44·8 }
IX	N	8	2,442	1,607	4,049	62·0	3·7	4·6	5·9	1·6	1·7	0·6
	D	8	1,553	1,292	2,845	56·1 } 59·05	20·1	8·1	9·2	1·4	1·7	0·8
X	N	8	3,488	2,319	5,807	60·9	6·1	5·4	5·7	4·6	5·4	1·5
	D	7	1,590‡	1,328‡	2,918‡	55·4 } 58·15	19·1	4·5	5·3	3·3	3·2	0·9
XIII	N	8	2,012	2,135	4,147	49·0	5·3	5·6	6·2	4·1	4·0	1·4
	D	8	1,177	1,568	2,745	43·7 } 46·35	16·7	6·2	6·0	2·5	2·8	1·0
XV	N	4	655	574	1,229	51·7	4·1	3·7	3·3	3·2	3·5	1·6
	D	4	697	561	1,258	59·2 } 55·45	17·9	4·7	4·4	3·2	4·1	0·8
XVI	N	8	2,179	2,594	4,773	45·2	5·8	4·5	5·4	3·9	4·1	1·3
	D	8	1,807	2,925	4,732	36·3 } 40·75	15·6	4·8	5·2	3·1	2·9	0·9
Average (all *stocks) Plot N.	4 lime-sulphur with nicotine and sulphite lye					**57·35**	**4·77**	**4·79**	**5·47**	**3·35**	**3·61**	**1·18**
Average (all *stocks) Plot D.	3 lime-sulphur with Derris and sulphite lye					**54·02**	**16·84**	**4·89**	**5·14**	**2·96**	**3·35**	**0·95**
% Reduction due to Treatment							84% N 44% D	26% N 24% D	12% N 18% D	94% N 95% D	96% N 96% D	97% N 98% D

* Sprayed trees only. † All trees on No. VI Stock were unsprayed controls. ‡ Totals from 6 trees only.

degree the "set"* of fruit on Plot D. It is much more likely, however, that the increased total set on Plot N was primarily due to the larger size of the trees.

Past experience in these experiments (4, 7) of the value of spraying in increasing the yield of fruit is amply supported by the present data. Of the set fruit, the average percentage picked per rootstock from sprayed trees on Plot D and Plot N was over fifty in nearly every instance. When compared with that percentage on treated trees in 1931 and 1932 (7) (discounting spray-induced fruit-drop), this figure is high, especially having regard to the heavy set in 1933, when natural thinning—the so-called "June-drop"—is expected to be considerable. The chief exception is provided by trees on stock No. XVI, which have not yet carried a high proportion of fruit to maturity in any season. A possible explanation of this has already been suggested elsewhere (7). The low figure (38·2 per cent.) on control trees is sufficient testimony of the "invisible" *loss* of crop (as well as ruination of what crop there is) caused by insect parasites and by Scab where spraying is not practised.

It will be noted that the percentage of fruits picked from trees worked on the various rootstocks is by no means constant. This variability is probably due to the influence of pomological factors outside the scope of the present paper, and possibly, in some measure, to past history of the trees.

Apple Sawfly (*Hoplocampa testudinea* Klug.). The percentage reduction of infestation due to spray-treatment was 84 on Plot N and 44 on Plot D. It would be unwise to lay undue stress on the results achieved in one season; nevertheless, the data are sufficiently consistent to leave no reasonable doubt that Sawfly was very effectively controlled by lime-sulphur, nicotine and sulphite lye, applied, as a combined wash, *at least four days prior to hatching of the eggs*. Derris with lime-sulphur and sulphite lye was approximately half as effective, but, in our present state of knowledge, the control given by this insecticide as used was not sufficient to recommend its use specially against Sawfly *in the routine, petal-fall Scab-spray*.

Of nicotine, it must be remembered that application was made (at petal-fall) in excellent weather conditions, fine and warm—conditions that are admirably favourable for that insecticide to function effectively. Under adverse weather conditions, dull and cool, it might not be nearly as effective. Nevertheless, such conditions are sometimes encountered when nicotine and soft soap are applied a week after petal-fall; the control obtained from season to season is subject to weather conditions whatever spraying programme is adopted.

The combined lime-sulphur-nicotine-sulphite-lye spray, *applied at petal-fall*, must be regarded as very promising from the standpoint of Sawfly-control. In comparison with the standard control method of applying nicotine and soap a week or so after petal-fall, following lime-sulphur with arsenate applied at petal-fall for Scab and caterpillar, it has the advantage of eliminating one spraying operation. A further great asset is obviation of the russeting that results from the present use, at short intervals, of lime-sulphur with lead arsenate and of nicotine with soap (7).

Caterpillar (*Winter Moth, Tortrix, etc.*). Neither nicotine nor Derris greatly reduced the proportion of fruits bitten by caterpillars. The percentage attacked was very low, even on control trees. It is worthy of note that, in relation to the percentage of the whole crop affected, a slightly higher proportion of attacked fruits was picked from sprayed trees than from controls, which suggests that spraying caused retention on the

* "Set" is used throughout this paper in reference to the total number of blossoms which, whether completely or incompletely fertilized, produced recognized fruitlets. The figure, for the purpose of these experiments, is the sum of picked and dropped fruits for each tree.

trees of fruits that otherwise might have dropped. It is not possible to determine from the data whether this was directly due to checking of caterpillar-attack or to the added effect of Scab-control on bitten fruits on sprayed trees.

In a season of severe caterpillar-attack, it would at present appear that the inclusion in the spray-programme of lead arsenate, as well as of a contact insecticide, may be desirable. Further knowledge of the potentialities of insecticide sprays, however, may render this unnecessary.

Red Spider (*Oligonychus ulmi* Koch). Records of infestation were not made, but incidental observation showed that sprayed trees were notably free from this pest while the controls were rusty-coloured by the end of June. During the latter part of the season, several of the sprayed trees showed signs of red spider-attack, and it was concluded that infestation had spread from the controls when the potency of the lime-sulphur on sprayed trees had diminished, and from the interplanted Stirling Castle trees, which were not sprayed.

Scab (*Venturia inaequalis* Aderh.). Excellent control of Scab was given on both Plots D and N. The extra pre-blossom lime-sulphur spray applied on N made no difference to the degree of control ultimately obtained, in spite of the fact that many trees on both plots had been unsprayed controls for several years until 1933. The seasonal conditions in Spring, 1933, were very different from those in Spring, 1932, when two pre-blossom applications had resulted (exceptionally for East Malling) in better Scab-control than one (7). In 1933, spring weather was generally fine, dry and warm, and this proved favourable for tree-growth and unfavourable for Scab. In 1932, dull, wet and cool conditions prevailed in Spring; these favoured the fungus and were detrimental to tree-growth. The effect of spray-treatment in the two seasons proved to be largely governed by these differences in weather conditions.

Thus it cannot be maintained that such excellent results will always follow the application of a spray-programme such as that tested in the present instance. Yet the fact remains that the lime-sulphur was used up till the " three-weeks " spray at weaker concentrations than formerly, and that, on control trees, there was very heavy infection (an average of 88·55 per cent. picked fruits infected) in spite of the dry season. As in the case of Sawfly, therefore, the combined spray must be regarded as very promising from the standpoint of Scab-control. It may even be found, after further experiment, that there is no necessity to reduce the concentrations of lime-sulphur used, but at present it is a safe premise on which to work.

Little can be gained from examination of the results in Scab-control as computed by different methods (last three columns in the tabulated data), for infection on sprayed trees was so slight as to render this unprofitable. However, on control trees, the difference between the average percentage of all fruits infected (57·30) and that of only picked fruits infected (88·55), shows that the dropped fruits were only lightly scabbed in comparison with those picked. This further indicates that widespread incidence of Scab on the fruits was not of very early* occurrence, inasmuch as the small, dropped fruitlets escaped infection. The average Scab-equivalent (38·70) of picked fruits on control trees was also very high, showing that not only was a high percentage of them infected, but the infection was of a severe nature. It appears to be true, therefore, that while in a dry season such as 1933, effective Scab-control by spraying can be much more easily carried out than in a wet one, yet the incidence and development of the disease can result in very severe infection on *unsprayed* Scab-susceptible trees, in spite of dry

* i.e. not early enough to cause them to drop freely.

weather conditions. This point was formerly noticed (3) during a season (1929) when drought conditions were experienced, and it was suggested that heavy dews were mainly responsible for the steady development of Scab on unsprayed, susceptible trees, in the absence of sufficient rainfall to account for it.

With such slight infection on all sprayed trees, it would not be profitable to discuss the influence of rootstock, which was probably masked by the effectiveness of the spray-treatment.

The Wetter and Spreader. Evidently sulphite lye, used instead of soft soap, showed great promise as a wetter and spreader, though the incorporation of lime-sulphur appeared to be necessary for good cover. However, this may possibly be due to lack of certain undetermined technique, as further work will show. Martin (2) has drawn attention to a disadvantage of its use, i.e. that it is at present an unstandardized product, while little is known of the chemistry of its manufacture. He states, however, that " The concentrated lyes which I have so far examined show no marked differences as spreaders, but, in the absence of methods of standardization, I have suggested a strength of three-quarters of a gallon of lye of 60° Tw. per 100 gallons, which is well above the minimum necessary to impart sufficient spreading properties to enable the spray to wet patches of the hop powdery mildew easily. This high concentration is made practicable by the cheapness of the material and by the wide margin of safety which appears to exist before injury is caused to plant foliage."

Summary.

Excellent control of Apple Scab, Red Spider and Sawfly was given on Cox's Orange Pippin in 1933 by employing a programme of sprays in which lime-sulphur was used in combination with nicotine, with sulphite lye as wetter and spreader. Reasons are given to show that *the effect of the nicotine against Sawfly was ovicidal.* Where Derris was the contact insecticide used, the effectiveness of the combined spray against Sawfly was reduced by about one-half, while against Scab it remained excellent. Lead arsenate was not included in the programme, and control of caterpillars of the Winter Moth group, etc., by the contact insecticides was indifferent, although infestation of fruits on unsprayed control trees reached only about 6 per cent.

Two pre-blossom lime-sulphur sprays gave no greater efficiency against Scab than one. Large crops of fruit were borne by all sprayed trees, and the phytocidal effect of heavy applications of lime-sulphur at a strength reduced from normal was negligible. Excellent weather conditions prevailed throughout most of the season and, while Scab-infection on unsprayed trees reached severe proportions, the dry weather greatly aided the effectiveness of control measures employed.

Acknowledgment.

The writer is indebted to Mr. W. Steer, of the Entomology Section, for his helpful suggestions concerning the entomological aspects of this paper.

References.

(1) Hey, G. L. and Steer, W. " Experiments on the control of the Apple Sawfly *Hoplocampa testudinea* Klug. The results of one season's field trials and some considerations arising from them." E. Malling Res. Sta. Ann. Rep. for 1933 (1934), 197-216.

(2) MARTIN, H. "The present uses and future development of spray spreaders." Hort. Educ. Assoc. Yr. Book, **1** (1932), 76-84.

(3) MOORE, M. H. "The incidence and control of Apple Scab and Apple Mildew at East Malling" (Part I). Journ. Pom. and Hort. Sci. (1930), **8**, 229-47. (Parts II and III.) *Idem* (1930), **8**, 283-304.

(4) ——— "Further studies on the incidence and control of Apple Scab (*Venturia inaequalis*) and Apple Mildew (*Podosphaera leucotricha*) at East Malling." (Parts IV, V and VI) Journ. Pom. and Hort. Sci. (1932), **10**, 271-94.

(5) ——— "Spraying trials against Pear Scab (*Venturia pirina*). Some practical and theoretical aspects of the interpretation of the results." E. Malling Res. Sta. Ann. Rep. for 1932 (1933), 99-108.

(6) ——— "Some incidental effects of routine Scab-sprays, with special reference to Apple Fruit Sawfly-control. A sidelight on the interpretation of field spraying experiments." E. Malling Res. Sta. Ann. Rep. for 1932 (1933), 90-8.

(7) ——— "Spraying and dusting experiments on the control of Apple Scab (*Venturia inaequalis*) and Apple Mildew (*Podosphaera leucotricha*) at East Malling in 1931 and 1932." Journ. Pom. and Hort. Sci. (1934), **12**, 57-79.

SOME FIELD OBSERVATIONS ON APPLE CANKER *(NECTRIA GALLIGENA)*

By M. H. MOORE

INTRODUCTORY.

The observations described in this paper were carried on simultaneously with and incidental to the spraying trials on Cox's Orange Pippin and Stirling Castle fully described elsewhere (1). As all details concerning the trees, the lay-out of the plot and the spraying experiments were given there, further reference to them will not be made here except for reasons of clarity in discussing results.

During winter pruning, records were taken of the incidence of Apple Canker on each tree, and infections were cut out as recorded. There was little opportunity, therefore, for the perithecial fructifications (typically crowded, crimson bodies often found on old cankers) of the fungus to develop, and they were rarely seen on these trees. The mode of dispersal of the fungus and the period when infection took place could not be studied, for time could not be spared from that required for the main line of work (Scab and Mildew-control). The records for several years have been summarized and classified, and they are discussed below in relation to spray-treatment and to rootstock.

At the beginning, some attempt was made to differentiate between the types of cankers, their positions on the tree and their relative importance to the tree. It was clear that a canker at the crotch, causing ultimate death of several main branches if not of the whole tree, was much more serious economically than a small canker girdling a two-year-old spur. Yet, in assessing the susceptibility of a tree to canker, it cannot be maintained that the canker at the crotch is any more significant than that on the spur. The position where the infection occurs appears to be greatly a matter of chance. Similarly, the size of the canker can scarcely be regarded as an accurate measure of susceptibility, since size (assuming a uniform rate of growth through tissues of different ages) must be largely governed by the part of the host plant involved. A canker on a small spur, for example, has not the same scope for development as one on the trunk. As soon as the twig is girdled it dies, and the canker can then extend only in one direction, towards the main branch. Meantime, a canker established at the crotch or on the trunk would have developed sufficiently to cover a much greater area than the spur canker, because of the greater scope afforded by its relative position on the tree.

In the light of these considerations, therefore, it was decided merely to count the canker-infections on each tree, regardless of their size and of their position on the tree. A further difficulty was encountered in recording results. Certain trees were grubbed in the early years, having been killed by canker which girdled the main stem. Had they lived, they might have shown further infections. The fact that they were killed by one infection was not necessarily due to greater susceptibility ; it was primarily because that infection (possibly unseen until too late to save the tree) had occurred in a vital part such as the crotch. It was therefore considered more justifiable to disregard these trees in the records than to record each as having one canker.

Incidence of the Disease in Relation to Spray-Treatment.

The trees were planted as maidens in 1921, and they have been short-spurred and leader-tipped every year since then. The pre-blossom spray was applied at pink-bud and the post-blossom sprays at petal-fall and again after three weeks. On account of severe damage to Stirling Castle caused by sulphur-containing sprays, the spraying experiment on this variety was discontinued at the end of 1928. On Cox's Orange Pippin, the same spray-treatment was given to each tree every year from 1926 to 1930 inclusive. Records of the incidence of canker in relation to spray-treatment have therefore been classified to cover a period of three years for Stirling Castle and five years for Cox's Orange Pippin.

The results are arranged in Table I.

The symbols used in the Table represent the following sprays:

Cox's Orange Pippin.

BM. Bordeaux mixture (burnt lime); 8-8-100 pre-blossom, 8-25-100 post-blossom.

LS. Lime-sulphur; 1-30 pre-blossom, 1-100 post-blossom (1-150 post-blossom on trees on No. VI. and No. X stocks).

CS. Colloidal sulphur; 0·4 per cent. post-blossom.

A. Lead arsenate paste; 0·4 per cent. pre-blossom, 0·3 per cent. post-blossom.

G. "Spray" gelatine; 0·1 per cent. post-blossom.

Stirling Castle.

LS. Lime-sulphur; 1-30 pre-blossom, 1-100 post-blossom (1-150 post-blossom on trees on No. VI and No. X stocks).

APS. Ammonium polysulphide; 1-100 pre-blossom; 1-200 post-blossom.

Liv.S. Liver of sulphur; 0·3 per cent. post-blossom.

CS. Colloidal sulphur; 0·4 per cent. post-blossom.

G. "Spray" gelatine; 0·1 per cent. pre- and post-blossom.

SS. Soft soap; 0·5 per cent. post-blossom.

All spray-concentrates used were obtained from normal commercial sources, except Bordeaux mixture, which was home-made.

Results.

Cox's Orange Pippin (1926-30 inclusive). There is no consistent evidence that any particular spray, applied to trees on the same rootstock at any one or all of the three periods, and repeated each year, gave cumulative control of canker. Inconsistencies in the data can evidently be explained by lack of uniform distribution of canker-infection, which is the subject of comment in a separate column. In fact, these inconsistencies would appear to be the most important issue arising from the tabulated data, showing as they do that the condition of any particular tree (as governed largely by soil conditions and rootstock) is a much more potent factor than the spray-treatment given in governing the degree of canker-infection on that tree. It was observed all through the period under review that certain trees developed a number of cankers every year, and once they began to show that tendency, they continued to canker freely, whatever spray-treatment was given.

When rootstock is disregarded, and a summary of records of canker-infection is made according to the kind of spray-treatment only, there is a slight suggestion that cumulative spraying reduced total infection over five years, especially where Bordeaux

COX'S ORANGE PIPPIN.

Total Cankers for five years, 1926-30 inclusive.

Spray-Treatment.	Stock.	No. of Trees.	Total Cankers.	Remarks.	Summary (grouping stocks). Treatment.	Trees.	Cankers.
1 pre-blossom :—							
BMA	I	5	3		BMA	20	55
LSA		5	11	8 on one tree.	LSA	20	42
A		6	7		A	24	72
BMA	II	5	12	6 on one tree.			
LSA		5	10	9 on two trees.			
A		6	3				
BMA	IX	5	8	6 on one tree.			
LSA		5	12	9 on one tree.			
A		6	3				
BMA	XVI	5	32	24 on two trees.			
LSA		5	9				
A		6	59				
2 post-blossom :—							
BMA	V	5	8		BMA	10	12
LSA		5	8	4 on one tree.	LSA	10	22
A		6	11		A	12	52
BMA	XIII	5	4				
LSA		5	14	9 on one tree.			
A		6	41	35 on two trees.			
1 pre- and 2 post-blossom :—							
BMA	XV	3	4				
LSA		3	2				
A		2	1				
BMA	III	5	2		BMA or BM	11	8
LSA		5	10	7 on one tree.	LSA or LS	11	17
A		6	7	6 on one tree.	A or Nil	10	15
1 pre- and 2 post-blossom :—							
BM	IV	3	2				
LS		3	5				
Nil		2	7				
2 post-blossom :—							
LSG	VI	5	1		LSG	10	4
CSG		5	2		CSG	10	11
G		5	8	4 on one tree.	G	10	16
LSG	X	5	3				
CSG		5	9	5 on one tree.			
G		5	8				

171 cankers on 102 treated trees.
155 cankers on 56 control trees.

RELATION TO SPRAY-TREATMENT.

STIRLING CASTLE.

Total Cankers for three years, 1926-28 inclusive.

ay-Treatment.	Stock.	No. of Trees.	Total Cankers.	Remarks.	Summary (grouping stocks). Treatment	Trees.	Cankers.	Average.
re-blossom :—								
LSG	I	5	3					
APSG		5	1					
G		6	0					
LSG	II	5	6	5 on one tree.				
APSG		5	4					
G		6	0		LSG	17	11	0·65
LSG	IX	2	2		APSG	18	7	0·39
APSG		3	0		G	21	3	0·14
G		3	1					
LSG	XVI	5	0					
APSG		5	2					
G		6	2					
ost-blossom :—								
LSG	V	2	0					
Liv.S. SS		2	0					
G		4	0		LSG	7	3	0·43
LSG	XIII	5	3	all on one tree.	Liv.S. SS	6	0	0·00
Liv.S. SS		4	0		G	10	10	1·00
G		6	10	4 on one tree.				
re- and 2 ost-blossom :—								
LSG	XI	3	0					
APSG		2	0					
G		3	0		LSG	6	0	0·00
LSG	XV	3	0		APSG	5	0	0·00
APSG		3	0		G	5	0	0·00
G		2	0					
ost-blossom :—								
APS. SS	IV	2	2		APS. SS	2	2	1·00
G		4	0		G	4	0	0·00
ost-blossom :—								
LSG	VI	2	0					
CSG		2	0					
G		4	0		LSG	7	1	0·14
LSG	X	5	1		CSG	7	0	0·00
CSG		5	0		G	10	0	0·00
G		6	0					

24 cankers on 75 treated trees.
13 cankers on 50 control trees.

mixture was used post-blossom only or pre- and post-blossom together. This is further supported by the broadest grouping of results into only two classes, (a) those on sprayed trees, and (b) those on control trees. By this method, no account is taken of the kind of sprays used or of the rootstock on which the trees are worked, and it will be seen that

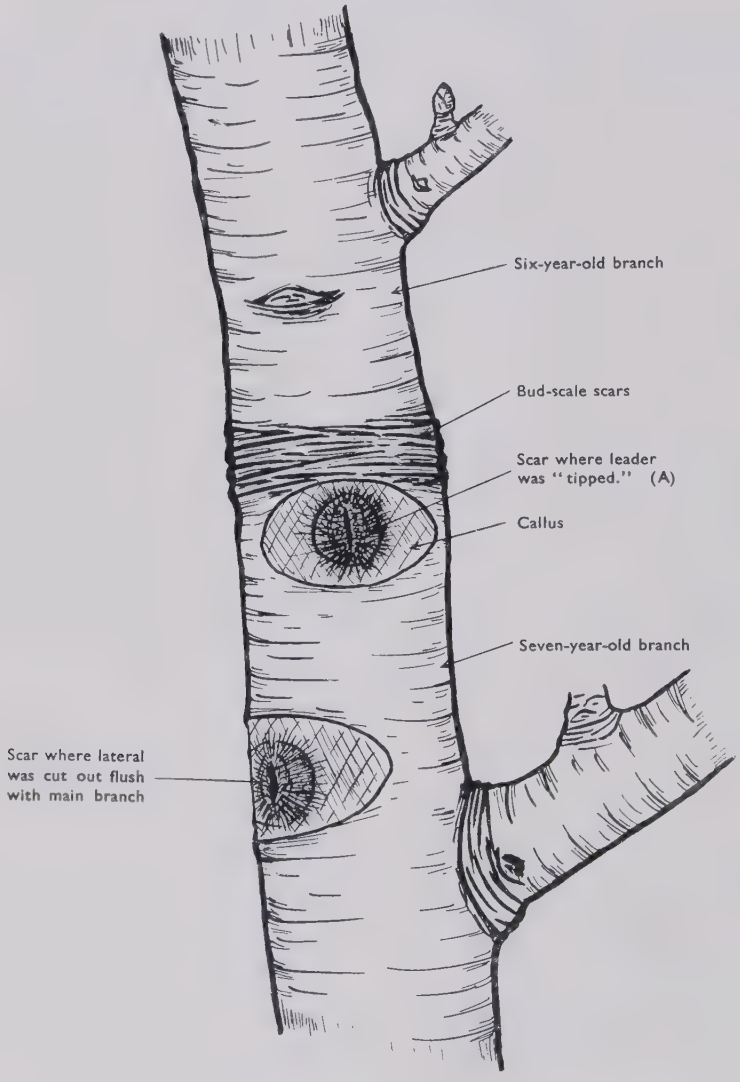


FIG. 1.
Showing well-healed scar where leader was " tipped " (A). Canker frequently started here.

there were nearly as many infections on control trees (155 cankers on 56 trees) as there were on almost double the number of sprayed trees (171 cankers on 102 trees).

Such moderate control might be merely an indirect effect due to suppression by spraying of other disease-producing agencies, for example, the Scab-fungus. Yet a large proportion of the cankers removed were found not on the younger but on the older

wood—from three- to six-year-old branches. Many of these infections originated at the scar denoting an apparently well-healed pruning-cut where the leader was "tipped" or where a lateral twig was cut out flush with the branch several years previously (see Fig. 1 and Fig. 2). A small, crater-like cavity may usually be found in the centre of

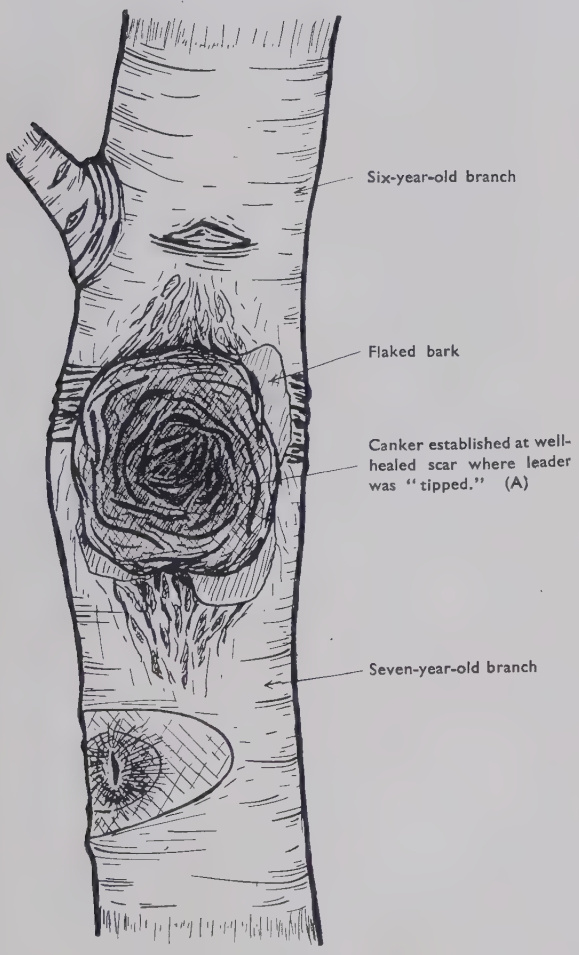


FIG. 2.
Canker established at (A) shown in Fig. 1.

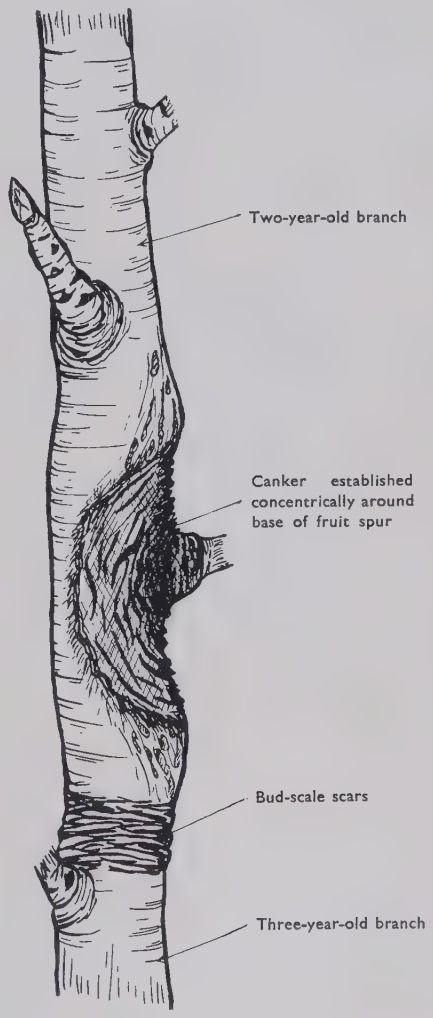


FIG. 3.
Canker at base of fruit spur.

such scars, where the callus has not quite met over the centre of the cut surface, and sufficient moisture may collect there to start infection. Possibly, as spray-fluid, too, must be held in these small craters, some control may be effected in that way. An infection on a branch sometimes developed concentrically around the base of a fruit-spur (see Fig. 3), or in the Y-shaped angle formed by diverging branches.

Stirling Castle (1926-28 inclusive). This variety, under East Malling conditions, proved to be, in general, less liable to canker than Cox's, although commonly it is regarded as one of the most susceptible of apple varieties.

The classified data in Table I show that, as with Cox's, distribution of canker-infection was not uniform, and that certain trees were much more susceptible than others on the same rootstock. There appears to be no clear relationship between the incidence of the disease and the kind of spray-treatment applied. A broad classification of results into only two classes, as with Cox's, (a) those on sprayed trees, and (b) those on controls, suggests that canker was slightly more prevalent on the sprayed trees (24 cankers on 75 trees) than on the controls (13 cankers on 50 controls). This might be connected with the excessive damage (leaf-drop) caused on this variety by sulphur-containing sprays—infection may have occurred through leaf-scars—although the data are so scanty that but little can confidently be deduced from them.

Incidence of the Disease in Relation to Rootstock.

Records of the incidence of canker are available from 1926-33 inclusive on Cox's* and from 1926-31 inclusive on Stirling Castle.† Certain trees of the latter variety were "top-worked" or were "over-budded" with Worcester Pearmain after 1931, so records of canker-infection were discontinued.

The data are classified in Table II.

Table II.

Apple Canker in Relation to Rootstock.*

Cox's Orange Pippin. Total cankers for eight years, 1926-33 inclusive.					Stirling Castle. Total cankers for six years, 1926-31 inclusive.				
Stock.	No. of Trees.	Remarks.	Total Cankers.	Average per Tree.	Stock.	No. of Trees.	Remarks.	Total Cankers.	Average per Tree.
I	16		34	2·13	I	16		20	1·25
II	16		63	3·94	II	16		33	2·06
III	16		40	2·50	IV	5	three died through canker	9	1·80
IV	8		33	4·13	V	8		7	0·88
V	16		57	3·56	VI	8		4	0·50
VI	15	one died through canker	24	1·60	IX	8		13	1·63
IX	16		49	3·06	X	16		2	0·13
X	15	one died through canker	59	3·93	XI	8		3	0·38
XIII	16		104	6·50	XIII	14	two died through canker	42	3·00
XV	8		15	1·88	XV	8		11	1·38
XVI	16		164	10·25	XVI	16		46	2·88

* Regardless of any spray-treatment given during the period.

* The spray-treatment given in 1931 and 1932 was different from that given from 1926 to 1930. That given in 1933 was different again.

† Spray-treatment ceased after 1928.

Results.

Although the period under review is eight years for Cox's and only six for Stirling, it is clear that Cox's was the more susceptible variety. A further point clearly shown by the results is the susceptibility of trees of either variety on the rootstocks No. XVI and XIII respectively. Cox's or Stirling's on No. II and on No. IV were susceptible to a less degree, while trees on No. X provided an interesting instance of differential effect. Cox's on this stock was relatively susceptible while Stirling was relatively resistant. A similar differential effect is seen to a less extent with No. V stock. Each variety was relatively resistant when worked on No. XV, VI and I respectively, while Stirling was also relatively resistant on No. XI. Cox's on No. III and on No. IX occupied an intermediate position, as did Stirling on No. IX.

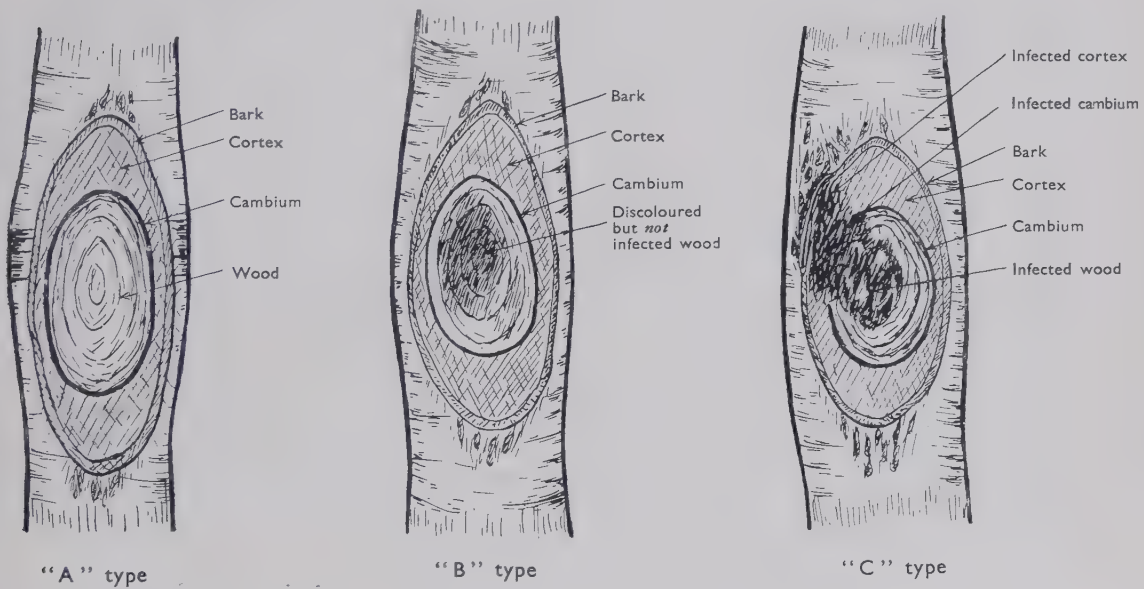


FIG. 4.

Showing three types of wounds made in the cutting-out experiment.

AN EXPERIMENT IN CUTTING OUT CANKERS.

While it was the usual practice in cutting out these cankers to pare the wound until no discoloured area remained in any part of the tissue, a small experiment was designed to determine whether complete cleaning of the wound was really necessary. To remove all discoloured wood (as distinct from bark, etc.) is often the most laborious part of the work, for, with a fairly old canker, this discoloration is often extensive and deep-seated.

Fairly large cankers on the main branches of certain Cox's trees on No. X stock were pared in three ways (see Fig. 4) on 14th March, 1932 :

1. quite clean and smooth (" A " type) ;
2. so that all *infected* tissue was removed, leaving *stained but not infected* wood* in the centre (" B " type) ;

* The *wood* was often discoloured brownish-red beyond the extent of infection, which could usually be satisfactorily determined. Infected wood was normally very rough and somewhat powdery, and was often flecked with whitish mycelium. When all this was removed, the surface, though stained, was quite smooth.

3. so that a strand of cankered tissue remained covering part of the wood, cambium and cortex (" C " type).

It should be mentioned here that a fairly sharp, hollow-ground chisel or gouge was used to dig into the tissues after the rough outer layers of the canker had been removed by a knife. The chisel was very satisfactory, and its use is strongly recommended for this work.

The wounds were all painted with grey lead paint, and left to callus. They were examined periodically during the following two growing seasons.

Results.

Of two " A " type, four " B " type and one " C " type wounds included in the experiment, all healed normally except the one " C " type. Here, although abundant callus was formed over the greater part of the wound, its growth was inhibited in the region of the strand of diseased tissue, which continued to develop as a cankered area. It is therefore concluded that cankered branches can be brought back to a healthy condition provided the canker is cut out before it has become very deep-seated (and, of course, before it has girdled the branch), and on condition that every scrap of *diseased* tissue is removed. *Discoloured wood* tissue may remain after the wound has been pared smooth, but it is not essential for perfect healing of the wound to remove this. It is probably a result of reaction in the healthy host tissue (on invasion of adjacent tissues by the canker fungus) in advance of infection, and therefore it contains no fungous mycelium.

An Experiment in Painting Wounds after the Removal of Cankers.

Although it is customary to paint wounds made in removing cankers in order to protect the tree from re-infection at those points, the wounds made on trees concerned in these observations were sometimes not protected, and in no instance was re-infection noted. Scrupulous care was always taken to pare every wound clean and smooth, and the cutting-out was nearly always done in early Spring (February or March) so that callus-formation began after only a relatively short interval.

It was decided to carry out an experiment to determine whether carefully-pared wounds required protection, and a trial of various materials used as paints was included.

Eight Cox trees on the canker-inducing No. XVI stock were selected for the experiment, which was carried out on 18th March, 1932. During that year, these trees were all sprayed with lead-arsenate paste (0·4 per cent.) + spray gelatine (0·1 per cent.) at pink-bud and at petal-fall, and with spray gelatine only (0·1 per cent.) three weeks after petal-fall, for they were control trees in a spraying trial against Scab. Control trees were chosen as it was thought that applications of fungicides might interfere with this experiment.

Thirty-one wounds were made in removing cankers on various branches of these eight trees, and the following materials were painted on :

Seven wounds painted with neat Colloidal Sulphur.
Six ,, ,, grey Lead Paint.*
Six ,, ,, neat Tar-Distillate.†
Six ,, ,, a bituminous Paint.
Six wounds were left unpainted as controls.

* White lead paint with a little black mixed in it for appearance sake.
† As used for winter washing.

Results.

Up to the time of writing (nearly two years after the experiment was made), not one of the wounds, unpainted controls included, has become re-infected. Neat tar-distillate burnt the bark and delayed callus-formation, which, however, occurred normally afterwards in spite of the burning. None of the other materials applied noticeably delayed callus-formation in comparison with that on unpainted control wounds. Neat colloidal sulphur did not long retain any properties of mechanical protection, for it tended to flake off after it became thoroughly dry. Grey lead paint was very persistent, while the bituminous paint provided a smooth, glossy surface which retained its mechanical properties for a very prolonged period.

It can only be concluded that, under the conditions governing this experiment, painting the wounds was not necessary to prevent re-infection by canker. It is not claimed that universal application of this practice of leaving wounds unprotected will always yield similar results—that is a matter for trial—yet it can confidently be stated that careful removal of cankers *at regular intervals* is a very important step towards confining the extent of infection to manageable limits.

Summary.

The kind of spray-treatment given to trees of Cox's Orange Pippin and of Stirling Castle over a period of years had little influence on the cumulative incidence of Apple Canker. Sprayed Cox trees in general, however, bore fewer cankers than control trees.

An influence of rootstock on scion-susceptibility to canker was observed. Both varieties were more susceptible when worked on No. XVI and on No. XIII than on any other rootstock.

The importance of cutting out all *infected* tissue when removing cankers is stressed. Any merely *discoloured* wood tissue remaining caused no resuscitation of the disease. A hollow-ground chisel or gouge is recommended for cleaning out the cankers.

A trial of different materials used as protective paints for the wounds is described. No infection occurred either of painted or of unpainted wounds.

Reference.

(1) Moore, M. H. "The Incidence and Control of Apple Scab and Apple Mildew at East Malling." (Part I) Journ. Pom. and Hort. Sci., **8** (1930), 229-47. (Parts II and III) *Idem.*, **8** (1930), 283-304.

ENTOMOLOGY

NOTES ON MITE AND INSECT PESTS FOR THE YEAR 1933

By A. M. MASSEE

1. The Hop Red Spider (*Tetranychus telarius* L.).

The Hop Red Spider has been very common in Kent and Sussex during the year 1933, and it caused considerable damage to the growth of many gardens during the months of July, August and the early part of September.

Although the Red Spider was present on the foliage throughout the Summer, in most instances it did not become conspicuous until about the middle of July. However, when it did commence to breed rapidly, the damage caused to the foliage became apparent in a very short while.

It is evident that many hop growers were not aware of its presence until an appreciable amount of damage had already been caused to the foliage, and by then the little silk webs under which the mites live and deposit their eggs were very conspicuous to the trained eye.

If Red Spider is known to exist in a hop garden in any one year, it is advisable to commence looking for it by examining the older leaves during June, so that if it is beginning to establish itself in numbers, measures can be taken to arrest its spread before it makes its web on the leaves.

The Hop Red Spider is generally present in most hop gardens, but it is more likely to be a nuisance in warm seasons. This is illustrated by the fact that it was particularly common in 1921, 1929 and again in 1933.

It does not seem to be generally known that the Hop Red Spider hibernates in the soil in the cracks of the poles and in old leaves, etc., during the winter months in the form of the adult female. This stage is brick red and is very conspicuous. The fact that it is more common in gardens when pole work is used in preference to wirework supports the view that it hibernates in the poles. Indeed if one splits open a pole during the winter time it is common to find the colonies of the little red mites tucked away in the sheltered cracks and crevices, and also in the holes made previously by a species of wood boring beetle.

If the drier positions of the soil (i.e. clods of earth on a mound, especially around the hills, and under stones) are examined, large colonies of the mites will be found hibernating there. These colonies are most easily found during October or November, but may be seen quite readily until the Spring.

This being so it is advisable to destroy the bine as soon as possible after picking in order to destroy the mites before they find time to migrate into the soil. Unfortunately this is not always possible because in some seasons they migrate while the picking operations are in progress. This phenomenon actually happened this year.

As regards soil treatment, very little advice can be suggested, but it has been found that a dressing of crude commercial naphthalene, applied at the rate of 3 to 4 cwt. per acre tends to reduce the mite population in the soil. It should be applied in the Autumn, say, in September or October, or failing that, in the Spring about the end of February or in March. The naphthalene should be applied mainly round the hills where the mites frequently hibernate.

Several recommendations have been made for controlling the mite during the growing season, but many of the suggestions are of little value, possibly because once the mite has formed its web on the underside of the leaf it is very difficult to get at it.

During the Summer considerable success has been obtained by spraying with Liver of Sulphur. The formula is as follows: Liver of Sulphur $\frac{3}{4}$ to 1 lb.; Soft Soap 5 lbs.; water 100 gallons. It is essential to apply the first application early, namely during July. A second and third application can be applied if necessary.

There is no doubt that the sulphur dustings and dressings which are normally applied to the hop garden for other purposes tend to check the ravages of this pest, but if the infestation is likely to be severe, the sulphur dusts alone are not sufficient.

2. The Fruit Tree Red Spider (*Oligonychus ulmi* C. L. Koch).

The Fruit Tree Red Spider has been very prevalent in most districts in Kent again this season, and the red eggs of this mite are very conspicuous at the present time (December) upon the spurs and branches of many sorts of apples, plums and damsons. This season it was also more abundant than usual on cherries, more especially on Morellos.

It was not abnormally common during the early part of the growing season, but as time went on it became a very serious pest. During the latter part of August many of the mites began to deposit their winter eggs on the leaves. This egg laying period proved to be about one month earlier than usual. Many of these so-called winter eggs hatched in September, and a majority of the young mites died before they matured. This unusual happening occurred in the Cambridgeshire district and at East Malling.

3. The Strawberry Tarsonemid Mite (*Tarsonemus fragariae* Zimm.).

The Strawberry Tarsonemid Mite proved to be more common in the South East of England than in recent years, and large acreages of strawberries were seriously affected by this pest. In many localities the mites were present in unusually large numbers during June, and by the middle of July many of the infested plants were showing definite signs of damage. The young runners in many plantations were subject to attack and many of them were killed before they became established.

One point of interest must be referred to here. Several plantations in the Maidstone area, which have been kept under observation during the two seasons previously and were found to be free from mites, were very severely attacked this year. The variety concerned was Royal Sovereign, and they were grown quite apart from other strawberry fields. The question one wants to answer is how the infestation started. In one case the attack commenced in the centre of the field, but this was not consistent in all fields. It is possible the mites were carried by wind, or by birds or insects, but this hardly seems likely. It is possible that a nucleus of the pest was present in the plantations concerned and that the favourable season favoured their reproduction and spread to other parts of the fields. More information in relation to the control of this mite will be found elsewhere.

4. The Strawberry Rhynchites (*Rhynchites germanicus* Hb.).

The Strawberry Rhynchites, a small blue weevil with a long trunk, is closely allied to the Apple Twig Cutter and the Apple Fruit Rhynchites, a red species which makes small round holes in the developing apple fruitlets.

The Strawberry Rhynchites does not attack the strawberry fruits, but acts in a similar manner to the Apple Twig Cutter. It bores in the strig of the fruits and bites

the petioles of the foliage. As a result of this form of attack many of the leaves wilt and the fruits drop off prematurely.

This insect has been reported from several localities around Maidstone, and it seems to be increasing in the East Malling district.

5. The Strawberry Leafhopper (*Typhlocyba rosae* L.).

The Strawberry Leafhopper, which also occurs on several other host plants, is far more common in commercial plantations than it is generally supposed. The Leafhoppers feed upon the undersides of the leaves during the summer and autumn months, and when they are present in considerable numbers the typical leaf mottling caused by these insects is plainly noticeable.

The Leafhoppers are not readily detected on the plants, but they may be seen hopping about from plant to plant when the foliage is disturbed.

At present it is not known what damage, if any, they cause to the plants, but in view of their prevalence in some seasons it is time preliminary investigations were started. The writer is indebted to Mr. W. E. China for the determination of the species.

6. The Strawberry White Fly (*Aleurodes fragariae* Wk.).

Another insect which has occurred commonly this year on strawberries is the Strawberry White Fly or Snow Fly. This insect is closely related to the Greenhouse White Fly and the species which has proved to be so common on cabbages this Autumn.

The White Fly which occurs on strawberries has a conspicuous black spot in the centre of the forewings, and thus it can be readily separated from the other two species mentioned above.

This insect feeds upon the leaves of the plants, and it is more readily noticed in the field during the autumn months. It continues to fly about during spells of cold weather, and in 1933 it was still on the wing at the end of October.

Very little seems to be known about this insect and its relation to the strawberry plant, but since it has been reported from several localities it seems worthy of mention.

7. A Tortrix from New Zealand (*Tortrix postvittana* Wlk.).

Three lepidopterous larvae were found in the fruits of the variety Cox's Orange Pippin on 23rd March, 1933. The apples in question had been imported from New Zealand some few weeks earlier. Two of the larvae died, but one of them continued to feed, and the moth finally hatched out on 1st June, 1933.

The moth was sent to Mr. T. Bainbrigge Fletcher and was determined as being *Tortrix postvittana* Walker. This determination was confirmed by Mr. E. Meyrick.

The Tortrix (*Tortrix postvittana* Walker) occurs in Australia, New Zealand, New Caledonia, and the Hawaiian Islands. It is said to be common in no less than eleven centres in Australia and it is considered to be a pest of economic importance.

It has been recorded in this country on a previous occasion by Mr. W. E. H. Hodson in 1927. The fact that this insect has been bred in this country on two occasions suggests that it may become established sooner or later in the south of England.

The moth has been deposited in the National collection at the British Museum of Natural History.

8. The Codling Moth (*Laspeyresia pomonella* L.).

The first brood of the Codling Moth has been present in many parts of Kent for many years, and curiously enough the caterpillar of this moth has been more prevalent in cottage gardens and small orchards than in large plantations. During the past few

years—and notably since 1927—this insect has been increasing in the county, and it occurs quite commonly in the Maidstone district, the Paddock Wood area, Canterbury, and more especially around Dartford. It is also common at Swanley and Southfleet. Now one of the most disturbing features about this pest is the fact that the second brood is becoming more common every season. In a sample of Bramley's examined from Belvedere no less than 80 per cent. were infested with the second brood larva of this insect.

The second brood larva does not enter the apple by the eye (the fact that the first brood larva of the Codling Moth normally enters the apple by the eye and concentrates on feeding at the centre of the fruit around the core and pips, at once separates it from the Apple Fruit Sawfly, which usually enters at the side of the apple, leaving a distinct hole at point of entry), but bores in at the side, leaving a hole somewhat similar to that made by the Apple Fruit Sawfly.

The second brood Codling caterpillar enters the fruits during the latter part of July and August, but the damage caused by it is not apparent until some weeks later. The fruits infested by the second brood larvae do not keep, and tend to ripen prematurely.

Now, one danger attached to the second brood is the fact that the larvae may be carried about from one farm to another in baskets and boxes used for packing the fruits. It has been noted this season and in previous years that when the fruit has been picked, packed and is ready for market, the larvae have the habit of leaving the fruits and frequently tuck themselves away in the crevices of the packages. Some remain there all the Winter, but many set off in search of better hibernating quarters, and it is these which prove to be a source of danger to the fruitgrower.

When it is realized that in certain parts of the United States of America no less than seven post-blossom applications of arsenical sprays are necessary to keep this pest in check, it will be apparent that it must not be allowed to spread at will in this country.

Where the second brood Codling occurs in numbers, it is advisable to trap some of the larvae by placing sack bands or corrugated cardboard bands around the trunks of the trees. If bands are already on the trees for the purpose of trapping the Apple Blossom Weevil it will not be necessary to put on fresh bands, since the same type of band will do for both these pests. The bands should be removed by the end of December at the latest, because by this time all the larvae which intend to go into them will have done so.

9. Apple Woolly Aphis (*Eriosoma lanigerum* Haus.).

The Apple Woolly Aphis has been very common again in many parts of the country. In fact it has not been so common since 1929, when it appeared to be a serious pest in some districts. It was also very abundant in 1921 which proved to be a very dry, warm Summer.

This year the Woolly Aphis was particularly prevalent in the Paddock Wood area, and it was definitely causing severe damage to trees of the variety Blenheim growing in a grass orchard. It was also common on Allington Pippins in the East Malling district, while reports concerning the control of this pest were received from many parts of Kent.

The Woolly Aphis colonies were noted on the trees during June and the infection spread rapidly until the new growths of the attacked varieties were materially affected.

Control measures have been attempted by some growers, but unfortunately with very little effect where the infestation was severe. It is true that an application of soft soap and nicotine, applied in late June, tended to check this pest, but it did not wipe it out, and after a few weeks the aphids were common again in the orchards. A summer

white oil applied at a strength of 2 per cent. has been used by some growers but the success obtained with this spray has hardly been worth while.

It would appear that a solvent is needed to dissolve the woolly secretion made by the aphids so that the sprays used can get into direct contact with the insects and thus destroy them.

It is a feasible proposition to paint over the infested patches of Woolly Aphis (where the infestation is not severe) by means of methylated spirit or petrol, applied with a brush. However, this method does not apply to a really badly infested orchard.

Details of the biological control of Woolly Aphis by means of the parasite *Aphelinus mali* Hald. will appear elsewhere in this report.

10. The Apple Blossom Weevil (*Anthonomus pomorum* (L.) Curt.).

This familiar pest has been very abundant in Kent and it has also been reported for the first time in one locality in West Sussex.

That the Apple Blossom Weevil is partial to certain varieties is well known. Therefore it is all the more disturbing to note that it is becoming more common on the variety Bramley's Seedling. It is also paying its attention to pears, and in some districts it is a serious pest on the variety Conference.

The weevil is frequently more common on cordon apples, especially dessert varieties, but it also occurs plentifully in grass orchards or in orchards which are surrounded by woods. Under such circumstances, the corrugated cardboard bands and sack bands, which are used for trapping the weevils, are not always efficient. This may be accounted for by the fact that there are plenty of alternative places in which the weevils can hibernate, whereas in a cultivated plantation the hibernation quarters are more limited.

Many weevils seek shelter at the bottom of hedgerows and in neglected, overgrown ditches, and such places should be kept clean if this insect is troublesome in the plantation.

11. The Plum Fruit Sawfly (*Hoplocampa flava* L.).

Although the Plum Sawfly has been known to exist in Kent for many years, it has not been considered to be a pest of economic importance until recently. Two years ago it was reported to be causing trouble in a plum plantation near Maidstone, and since that time it has been spreading to some of the larger plum growing areas. It was common at East Malling last year, and it also turned up again in new plantations in the district this Spring.

The habits of the Plum Fruit Sawfly are in some ways similar to those of the Apple Fruit Sawfly, and there is no need to give details here.

If evidence of this pest is detected in any commercial plantation, steps should be taken to notify the local Advisory Officer or some other competent person, so that measures can be taken to eradicate it the following season.

Summary.

Brief notes are given upon some important insect pests and mites which were prevalent in Kent and elsewhere during the year 1933.

Among the more important pests observed are the Hop Red Spider, the Strawberry Tarsonemid Mite, the Apple Blossom Weevil, the Codling Moth, the Apple Woolly Aphis, the Plum Sawfly, and a species of Tortrix Moth (*Tortrix postvittana* Wlk.) which was bred from an apple imported from New Zealand.

INVESTIGATIONS ON THE CONTROL OF THE STRAWBERRY TARSONEMID MITE

By A. M. MASSEE

Introduction.

It has been pointed out elsewhere* that a great deal of difficulty has been encountered in attempting to control the Strawberry Tarsonemid Mite because of its obscure habits. The majority of the mites dwell and feed in the most protected parts of the plants; in the cracks and crevices of the crowns, and in the young unfolded leaflets. In these circumstances it is very difficult to hit the mites with any spray material and in practice this has been found to be almost impossible. A 3 per cent. lime-sulphur spray will kill the mites if it comes into direct contact with them, but under field conditions this is impossible of achievement.

In view of this difficulty an attempt has been made to eradicate the mites from young plants before they are planted out in the field.

The Treatment of Royal Sovereign Strawberry Runners before Planting.

In October, 1932, an experiment was started to determine the value of treating strawberry runners before planting them out by sterilizing them in warm water and by dipping them in a lime-sulphur solution for a given period.

For the purpose of this investigation strawberry runners were obtained from a plantation which was known to be badly infested with mite throughout the Summer of 1932. Now in order to make sure that every plant was infested, five adult mites were placed on each at the commencement of the investigation.

Treatments.

The following treatments were used in the main trial:

1. Absolute controls.
2. Dipped in 3 per cent. lime-sulphur + Agral I for twenty minutes.
3. Sterilized in warm water for a period of twenty minutes at a constant temperature of 110° F.
4. Sterilized in warm water for a period of ten minutes at a constant temperature of 110° F.

Warm Water Treatment.

In this trial the temperature of 110° F. was decided upon since it had been shown in former preliminary experiments* that all the mites were killed at this temperature and that the plants were not injured provided simple precautions were observed.

The runners were treated in a Hearson's No. 2 bulb sterilizer which proved ideal for the purpose. The temperature was controlled by means of a thermostat, and it was found possible to keep a constant temperature quite easily. Before the plants were

* Massee, A. M., Further Observations on the Strawberry Tarsonemid Mite. *East Malling Res. Sta. Ann. Rep. for* 1932 (April, 1933), 117-31.

placed in the sterilizer the thermometer registered 111° F. Directly the plants were put in the temperature dropped to 109° F., but it steadily rose again to 110° F. after a few minutes and remained constant. When the plants had been sterilized for the required period they were removed and immediately plunged into a tank of cold water. This precaution was taken to prevent overheating which proves to be one of the chief causes of the death of the plants after the warm water treatment.

The series which were dipped in the lime-sulphur (3 gallons) + Agral I (2 lbs.) solution were treated as follows. The plants were contained in a muslin bag and were placed in a tank containing fifty gallons of lime-sulphur. A brick was tied to the bag to make it sink. The solution was stirred from time to time and the plants were left soaking for twenty minutes. On removal they were placed in potato trays and allowed to dry.

All the plants were treated on the 11th of October, and were planted out that afternoon and the day following.

Arrangement of Plots.

Six hundred and forty plants were used, consisting of four treatments of 160 plants. They were planted out in randomized plots consisting of twenty plants each. Thus each plot was repeated eight times, and each treatment was arranged so that it was adjacent to each of the other treatments. Thus the warm water treated plants were adjacent to control plants on one plot, and to the lime-sulphur dipped plants on the next and so on.

The arrangement of the plots was drawn up by Mr. T. N. Hoblyn, and it proved to be very suitable for this type of investigation.

Examination of Plots.

The plots were examined in detail at the end of October, and all the control plants were beginning to grow away very well. The foliage was green and the leaves were erect. In fact it was possible to pick out all the control plots from the rest without the aid of the labels.

All the plants dipped in the lime-sulphur solution were alive, the leaves were green, healthy and vigorous. Some of the young undeveloped leaflets at the crowns were scorched and brown in colour, and some of the leaves were killed by the treatment. It was also possible to pick out this treatment without reference to the labels.

The series treated in warm water for twenty minutes at a temperature of 110° F. were beginning to grow away. Three of the plants had died. Some of the older leaves were of a yellowish colour, and many of them turned back as a result of the treatment. However, the young leaflets at the crowns of the plants were commencing to grow and appeared to be quite normal.

The plants treated in warm water for ten minutes at a temperature of 110° F. were in a very similar condition to those treated in warm water for twenty minutes. Three plants had died, and the remainder were rather weak.

Both the warm water treated series were definitely weaker than the controls and those dipped in lime-sulphur.

The plots were examined from time to time during the winter months, and a detailed survey was made on the 12th April, 1933.

The control plants were growing away quite well. None of the plants had died. Many flower trusses were present, averaging two per plant. The foliage was bright green and the crowns were sturdy.

The plants dipped in lime-sulphur were not quite as sturdy as the controls, otherwise they were very similar. Flower trusses averaged two per plant. Four plants had

died. The plants were growing away healthily, and were about as advanced as the controls.

In both the warm water treated series all the plants were weaker than the check plants. They were not so sturdy, the fresh green colour of the foliage was lacking, and they were much more backward, and the flower trusses were only just beginning to show. In the series treated for twenty minutes seven plants had died, while fourteen of the plants treated for ten minutes had died also.

By the 24th May, 1933, the plants on all plots were growing quite vigorously. Indeed, a great change was noted on the warm water treated plots. In fact these plants were now growing so fast that they were equal in vigour to the dipped and control plants, and in fact many of them looked more robust. The runners were growing very quickly and they had already been removed four times. The flower trusses were also removed from time to time.

Survey of Insects Present on the Plants.

At the end of May a survey was made of the insects and mites present on all the plants. It was interesting to note that the aphis (*Pentatrichopus potentillae* Wlk.) (*=Capitophorus fragariae* Theo.) and the red spider (*Tetranychus telarius* L.) were not found on any of the plants. However, a species of Rhynchites (*Rhynchites germanicus* Hb.) was present on some of the plots. This weevil caused a little trouble on account of its peculiar feeding habits. It eats through the petioles of the leaves, causing them to wilt, and finally drop off. The weevils were present until August but were not seen since.

The Lygus Capsid Bug (*Lygus pabulinus* L.) was also noted feeding on the leaves of a few plants, but this insect was not troublesome to any extent.

At the beginning of June the Strawberry Tarsonemid Mite (*Tarsonemus fragariae* Zimm.) was commencing to damage some of the plants, and the damage caused by this mite was in evidence on each of the eight control plots.

A second survey of all the plants was made in August and very interesting facts were obtained. In the first place all the control plants, without exception, were showing very distinct mite injury, and many of the plants were so badly attacked that they were in a very unhealthy condition. The series dipped in lime-sulphur were very much healthier in appearance, but a close inspection showed that about 80 per cent. were found to be severely attacked, and a more detailed examination revealed the fact that all the plants were attacked to a greater or less extent.

Both series of warm water treated plants were comparatively free from attack. It was evident that those treated for only ten minutes at 110° F. were more severely infested than those treated for twenty minutes, but both treatments were comparatively free of mites when compared with the controls and those dipped in lime-sulphur. In fact mites were detected on only twenty-eight plants in the warm water treatment for ten minute series, while only five plants of the total were infected in warm water treatment for twenty minute series.

At the end of August the warm water treated plants were so much healthier than either the control or the lime-sulphur dipped plants, that even the layman could go on to the plots and pick out the warm water treated plants without any aid or previous knowledge of the lay-out of the plots. This is clearly demonstrated in Fig. 1 which shows a warm water treated plot with a control plot adjacent to it.

By the end of September the mite infestation became so severe that every plant in the trial became infested, including the warm water treatment plots. How the mites

spread so rapidly in the Autumn is a mystery, since all the runners were removed, and none of the plants on any one plot were in contact with plants on an adjacent plot.

During the summer months very few mites were noted on any of the warm water treated plots, and those present could only be detected with the aid of a binocular microscope. Therefore it is probable that the mites came in from the control plots and those which received the lime-sulphur treatment. They may have been carried by the aid of the wind or insects.

Production of Runners.

A record was obtained of the number of runners produced on each of the four treatments. The following figures indicate the total number of runners removed from each treatment during the middle of June, 1933. 1,712 were removed from the controls; 1,104 from those dipped in lime-sulphur; 1,352 from the warm water treatment for twenty minutes; and 1,072 from the warm water treatment for ten minutes. Thus it will be seen that while the greatest number of runners were produced on the control plants, those treated with warm water for twenty minutes were not far behind, and in fact they were continuing to produce more runners than the controls in July and it is probable that the totals would even up by the end of the season, since it must be remembered that the control plants commenced to produce runners earlier in the season than the treated ones. Also there were fewer treated plants alive than controls.

Height and Spread of the Plants.

Although it was clearly evident that the difference between the various treatments was very marked in the field, it proved a very difficult matter to express the difference in figures. An effort was made to record the total spread and height of all the plants at three periods of the growing season, and these are tabulated below.

First Record obtained 27/6/33.

Treatment.	*Average spread.*
Control plants	15·40 ins.
Lime-sulphur dipped plants	14·03 ins.
Warm water for twenty minutes at 110° F.	13·12 ins.
Warm water for ten minutes at 110° F. ..	13·40 ins.

Second Record obtained 18/8/33.

Treatment.	*Average spread.*	*Average height.*
Control plants	16·42 ins.	7·01 ins.
Lime-sulphur dipped plants	16·64 ins.	7·66 ins.
Warm water for twenty minutes at 110° F. ..	16·09 ins.	7·50 ins.
Warm water for ten minutes at 110° F. ..	15·86 ins.	7·15 ins.

Third Record obtained 28/9/33.	*Average spread.*	*Average height.*
Control plants	16·46 ins.	5·46 ins.
Lime-sulphur dipped plants	17·59 ins.	6·20 ins.
Warm water for twenty minutes at 110° F. ..	17·40 ins.	6·79 ins.
Warm water for ten minutes at 110° F. ..	16·80 ins.	5·80 ins.

It will be seen from the figures that while the average spread of the control plants was greater at the end of June than in any of the other treatments, this advantage was gradually lost, and by the end of September the warm water treated plants had actually caught up in the average spread, and in fact they were slightly larger than the controls.

The figures for the average height are also interesting. In August the average height of the plants in all treatments was approximately the same, whereas in September although the average height of all treatments was considerably less than in August, the height of the plants treated in warm water for twenty minutes was considerably greater than the controls. This fact was more striking in the field than the figures suggest.

The Presence of "Yellow Edge" Disease.

A further survey of the plots was made on the 19th October, 1933, and a record of the presence of the virus disease "Yellow Edge" was obtained.

This may be summarized as follows.

Treatment.	*Percentage of "Yellow Edge".*	*Percentage Doubtful Cases.*	*Percentage Healthy Plants.*
Control plants	23·12	27·5	47·5
Lime-sulphur dipped plants ..	9·37	12·5	73·75
Warm water for twenty minutes at 110° F.	8·12	23·12	63·12
Warm water for ten minutes at 110° F.	20·62	15·0	55·0

The above table does not take into account the mortality of the plants in the various treatments. This works out as follows:

Control plants 1·86 per cent.; Lime-sulphur dipped plants 3·37 per cent.; Warm water for twenty minutes 5·62 per cent.; and Warm water for ten minutes 9·37 per cent.

Although it is not possible to suggest the cause of the death of the plants, it seems reasonable to assume that the virus disease "Yellow Edge" was responsible in some instances. The virus disease was spread pretty evenly all over the plots, but the characteristic "Yellow Edge" symptoms were not by any means clearly defined in all cases, and these are indicated in the column headed "Percentage Doubtful Cases".

The observations on "Yellow Edge" disease do not indicate that the disease is being carried by the mite, since far fewer cases of the disease were noted on the lime-sulphur dipped series than on the controls, whereas the number of mites on these two treatments was approximately the same.

The strawberry aphis was not present on any of the plants throughout the season, so in this experiment at least it cannot be considered to be the vector of the disease.

One possible explanation is that the plants were already infected with the virus when they were planted out the previous October. In fact several of the plants looked very suspicious although definite virus symptoms were not actually present.

Conclusions.

As a result of this investigation and other preliminary work on the warm water treatment of strawberry plants, together with observations obtained from growers' plantations where the treatment has been carried out on a field scale, it is abundantly clear that the warm water treatment of strawberry plants should become a matter of routine for the practical grower. This year's results show very definitely that the plants must be sterilized in warm water for a period of not less than twenty minutes. Although the treatment for ten minutes tends to reduce the mite population considerably, it is not sufficiently long to destroy all the mites and it would seem that those tucked away in the crowns of the plants are not affected. However, several points of the utmost importance must be strictly observed.

The temperature of 110° F. for a period of twenty minutes must be strictly adhered to, and a reliable thermometer should be used.

The treatment is more successful if the plants are put into the tank loose, and not tied up in bundles as is often the practice. For convenience the plants can be contained in cauliflower or sprout nets. If they are treated tied up in bundles, it is essential to cut the strings immediately after treatment.

It is also essential to cool off the plants as soon as possible after treatment. This can be done by plunging them into cold water, when this has been completed the plants are ready for planting out.

It is not yet known whether all varieties will stand the same treatment without being injured, but such varieties as Royal Sovereign, The Duke, Paxton, Oberschlesien, Stirling Castle, and Stirlingworth can be treated without causing any harm to the plants. About 2 per cent. of the treated plants may die, but these are generally the weak ones which would be of very little value anyway.

Experience shows that the best time to carry out the treatment is somewhat limited. The latter part of August and September are the better months in the Autumn, while March and April are to be recommended for the spring treatment. It has been observed that if plants are treated from the latter part of October until the end of February many of them will die. This may be due to the fact that they remain in the soil without establishing themselves and without making roots.

Other Investigations in Connection with the Control of the Strawberry Tarsonemid Mite.

In order to determine the exact effect of the warm water treatment upon the mites and other insects, and also the effect of the treatment upon the growing plants, a series of experiments were carried out in the Autumn of 1932.

For this purpose wide ranges of temperatures were included varying from 130° F. to 90° F., and the plants were treated for periods of ten and twenty minutes respectively. Eighty plants were used in each treatment.

The treatments were as follows:

Twenty minutes at 130° F.
Twenty minutes at 120° F.
Ten minutes at 120° F.
Twenty minutes at 115° F.
Ten minutes at 115° F.
Twenty minutes at 105° F.
Ten minutes at 105° F.
Twenty minutes at 100° F.
Ten minutes at 100° F.
Twenty minutes at 90° F.

All the plants treated were of the variety Royal Sovereign, and all were known to be infested with the Strawberry mite. They were all treated in a Hearson's Bulb Sterilizer as used in the previous experiment. The treatments were made in the beginning of October, and the plants were planted out the following day.

Observations were made on the plants throughout the winter and spring months, and the effect of the temperatures upon the mites were noted.

All the plants treated at a temperature of 115° F. for twenty minutes and those above this temperature died during the first week after being planted out. Thus it

[Photo W. Steer

Left - Warm water treated plants. Right - Untreated plants.

(Photograph taken 4/9/33.)

seems evident that the death point of the plant is somewhere in the neighbourhood of 115° F. It is interesting to note that the plants treated at a temperature of 115° F. for a period of ten minutes were not injured at all by the treatment. All the plants treated at a temperature lower than 115° F. were not injured as might well be expected.

At the other end of the scale some interesting facts were obtained. When the plants were treated at a temperature of 105° F. for twenty minutes, and at the temperatures lower than this, the treatments had no effect upon the mites or their eggs.

It is therefore clearly indicated that if the temperature is allowed to rise to 115° F. for a period of twenty minutes all the plants will be killed; conversely, if the temperature drops to 105° F. the mites and their eggs will not be destroyed. This was particularly striking in the field during the Spring of 1933. All the plants treated at a temperature of 105° F. or less were literally smothered with mites.

From the above observations it may be concluded that the best temperature to use is that in the neighbourhood of 110° F. It has been found that no harm will be caused to the plants should the temperature rise to 112° F., or that the effect on the mites will not be lessened should it fall to 108° F. Thus for practical purposes a temperature ranging between 108° F. and 112° F. should be aimed at.

Finally, the effect of the warm water treatment at a temperature of 110° F. upon other insects and mites is of importance.

It has not been possible to make any detailed investigations on this point, but some observations are worth recording in brief.

None of the treated plants were attacked by Red Spider or by the Strawberry aphis, and both these pests have been observed to be killed by the warm water treatment. In addition it seems likely that the strawberry eelworm is killed by the same treatment, and if this proves to be the case, then at least three other important pests will be destroyed in addition to the Strawberry Tarsonemid Mite.

Summary.

Investigations in relation to the control of the Strawberry Tarsonemid Mite are described.

It is shown the mites can be destroyed on young plants, by sterilizing them in warm water, before they are planted out.

The plants should be treated at a temperature of 110° F. for a period of twenty minutes.

When treated for a period of ten minutes at 110° F. the results are not so pronounced.

The effect of dipping the plants in a lime-sulphur solution (3 per cent.) for a period of twenty minutes is also discussed. The results from this treatment are not encouraging.

Experiments have also been carried out to determine what temperature is necessary to destroy the mites and their eggs, without at the same time injuring the plants.

Special attention is drawn to the correct times of carrying out the treatment.

Finally, the effect of the warm water treatment upon other mites and insects is briefly discussed.

STUDIES ON *BYTURUS TOMENTOSUS* FABR.

IV 1933 EXPERIMENTS ON THE CONTROL OF THE RASPBERRY AND LOGANBERRY BEETLE

By W. STEER

INTRODUCTION.

Previous papers in this series (4, 5, 6) have described a very effective and practical method of controlling the Raspberry Beetle on both raspberries and loganberries. This method, which has been successfully employed also by Kearns and Walton (1) and by Petherbridge and Thomas (3), consists of spraying twice with Derris and soft soap, once about the middle and again towards the end of June.

Experiments carried out at East Malling in 1932 (6) suggested that the second (late June) of the two sprayings is by itself sufficient and that the first would prove superfluous. The evidence further suggested that a very late spraying (shortly before picking begins) might with advantage be given to loganberries in order to improve the quality of the later pickings of fruit, which, even on sprayed bushes, were usually rather badly infested. These two issues formed the main part of the investigations reported in this paper.

A further possible method of improving the quality of the later berries, without having recourse to an additional spray, seemed to be to improve the sticking properties of the late June spray by the addition of gelatine. This was tested in a subsidiary loganberry trial.

As regards raspberries, in addition to the number of sprays necessary and their proper time of application, it seemed desirable to investigate further the value of Derris dust and to gain some preliminary knowledge of the value of Cubé (Barbasco) as an insecticide.

Spray Materials.

The Derris root used for all the trials of Derris carried out at this station in 1933 was a finely ground sample purchased in bulk from a large firm of insecticide manufacturers. For use as a spray it was mixed with soft soap and water at the following rates :

Derris	.. .. ..	2 lb.
Soap	.. .. ..	5 lb.
Water	.. .. ..	100 gallons.

The " Cubé " or " Barbasco " root (*Lonchocarpus* spp.) was supplied by Dr. Tattersfield. This was less finely ground than the Derris, but with constant agitation proved suitable for spraying purposes. It was mixed with soap and water at the following rates :

Cubé ..	.. .. ..	1 lb.
Soap ..	.. .. ..	5 lb.
Water	.. .. ..	100 gallons.

Analyses of these two substances made by Dr. Tattersfield gave the following results :

Derris Root.

Crude rotenone per cent., 2·67, 2·75. Mean 2·71.
Re-crystallized rotenone per cent., 2·23, 2·41. Mean 2·32.

Cubé.

Crude rotenone per cent., 6·15, 6·38. Mean 6·26.
Re-crystallized rotenone per cent., 5·21, 5·33. Mean 5·27.

As used in the field the sprays thus had approximately the same rotenone content, the Derris containing 0·0054 per cent. and the Cubé 0·0064 per cent. (as crude rotenone).

The dust used in the raspberry dusting trial was composed of 3·7 per cent. by weight of Derris and 96·3 per cent. of China clay, and thus contained 0·1 per cent. (crude) rotenone. This was about the same rotenone content as that of the Derris dusts used here in two previous seasons.

Application of Sprays and Methods of Recording Results.

The sprays were all applied by means of a Cascade hand pump machine supplying a single nozzle at a pressure of about 200 lb.

The data on fruit infestation were in all cases obtained from random samples. The sampling method and the details of plot layout differed in no way from those employed in the 1931 and 1932 experiments, and since they have already been fully dealt with (5, 6) it is unnecessary to describe them here.

1933 TRIALS.

Raspberries—Dusting Trial.

In previous experiments carried out at this station (5, 6) three applications of a Derris dust containing 0·09 per cent. rotenone gave good results on raspberries. Thus in 1931 dusting on 10th, 17th and 23rd June reduced the attack from 44·4 to 8·4 per cent. and in 1932 dusting on 13th, 20th and 27th June reduced it from 75·5 to 12·5 per cent. Although the first, and possibly the second, dusting may in each case have contributed to the result by killing adult beetles, it was felt that the reduction of the damage was largely due to the toxicity of the dust to the larvae.

Kearns and Walton (1) in 1932 reduced an attack on raspberries from 34·9 to 2·7 per cent. by dusting on 20th and 24th June. This treatment doubtless acted mainly on the larvae. On loganberries they reduced an attack of 29·9 to 9·3 per cent. by dusting on 17th and 25th May and 3rd June. The dates of application suggest that in this case control was obtained largely by killing the adult beetles.

Petherbridge and Thomas (3) obtained excellent results on loganberries in 1932 by means of a single dusting, applied to kill the adult beetles before they laid their eggs. One application of dust (7th June) reduced the attack from 69·1 to 7·4 per cent. Two dustings (2nd and 7th June) gave a very similar result, reducing the attack to 4·5 per cent.

Parker (2) in 1932 dusted loganberries on 2nd, 14th and 27th June, and reduced the percentage of damaged berries from 44·4 to 10·3. His first and second dustings would be mainly concerned with the adult, whilst his third (and possibly second) dusting would be effective against larvae.

In view of these results it seemed desirable to test the value of a Derris dust as a means of attacking the adult beetles rather than the larvae.

Layout. The trial was carried out on one-fifth of an acre of Lloyd George raspberries. This material was divided into eight plots, two plots being allotted to each of two dusting treatments and four plots left untreated as controls.

The treatments were as follows:

1. Dusted 9th May.
2. Dusted 30th May.
3. Controls (not dusted).

Application. The dust was in each case applied early in the morning by means of a Niagara rotary hand duster. The rate of application was about 100 lb. per acre.

The first dusting (9th May) was given when bud damage by the adult beetles was becoming noticeable.

The second dusting (30th May) was given about a week after the beginning of oviposition but *just before the majority of the eggs were laid.*

Results. The results are shown in Table I.

TABLE I.

RASPBERRIES. EFFECT OF A DERRIS DUST CONTAINING 0·1 PER CENT. ROTENONE.

Percentage Infested Berries.

Date of Sampling.	Dusted 9th May.	Dusted 30th May.	Controls (not dusted).
26th June	43·0	26·5	49·7
29th June	51·5	28·5	51·2
3rd July	52·5	23·0	53·7
7th July	86·5	51·0	84·7
14th July	67·0	66·0	74·0
Average	60·1	39·0	62·7

The earlier dusting evidently did not affect the subsequent infestation of the fruit. The later dusting did reduce the infestation somewhat, but only in the earlier pickings of fruit.

The date of the single heavy dusting (7th June, 1932) given to loganberries by Petherbridge and Thomas can be regarded as approximately equivalent to the date (30th May, 1933) on which the later of the two dustings was given here, since 1933 was an earlier season than 1932. The superiority of their results may have been due to their heavier rate of application (3 cwt. as compared with less than 1 cwt. per acre) or to the higher rotenone content of the dust which they used (0·2 as compared with 0·1 per cent.).

Raspberries—Spraying Trial.

Objects. The objects of this trial were (a) to determine the relative values of the first (mid-June) and the second (late June) applications of the double spraying method, and (b) to gain information as to the use of Cubé in the field.

Layout. This trial was carried out on two-thirds of an acre of Lloyd George raspberries consisting of twelve long rows. The layout adopted was similar to that

used with success in previous seasons and consisted of four randomized blocks, the six treatments being arranged at random within each of the blocks.

The treatments were as follows :

A. Derris, sprayed once, 6th June.
B. Derris, sprayed twice, 6th and 16th June.
C. Derris, sprayed once, 16th June.
D. Cubé, sprayed once, 16th June.
E. Unsprayed.
F. Unsprayed.

One series of plots (E) should have received nicotine but, through shortage of time, was not sprayed at all and was subsequently regarded as a duplicate control series.

Application. The first spraying (6th June) was given three days after hatching was first observed and is approximately equivalent to a mid-June application in a normal season.

The second (16th June) was given after the larvae had begun to attack the fruit. Commercial picking started on 21st June, only five days after spraying. Many fruits were ripe and a light picking could actually have been made at the time of spraying. It was then felt that spraying was at least three days too late to prevent serious damage to the earlier pickings.

TABLE II.

RASPBERRY SPRAYING TRIAL.

Percentage of Infested Fruits.

Date of Sampling.	Sprayed with Derris and Soap.			Sprayed with Cubé and Soap once, 16th June.	Controls—not sprayed.	
	Once, 6th June. A	Twice, 6th and 16th June. B	Once, 16th June. C	D	E	F
22nd June	2·7	0·7	10·7	15·5	57·5	55·5
26th June	2·0	0·5	6·2	5·7	56·0	53·5
29th June	4·2	2·0	5·0	5·5	54·7	58·0
3rd July	13·5	2·2	5·0	5·7	58·0	62·5
7th July	13·0	1·5	6·2	6·5	73·2	75·2
12th July	17·7	3·2	8·0	4·0	72·5	64·7
14th July	24·7	3·0	11·2	7·7	73·7	74·5
18th July	32·7	6·0	11·7	6·7	63·0	60·0
Average of eight pickings	13·8	2·4	8·0	7·2	63·6	63·0

Analysis of Treatments A, B, C and D.

	General Mean.	Standard Error.	Significant Difference.
Individual pickings	7·87	1·86	**5·3**
Eight pickings	7·87	0·66	**1·9**

Results. The data afforded by random samples taken on eight occasions during the picking season are set out in Table II. In comparing the effect of the four spray treatments differences of 5·3 are significant at any one period during the picking season ; as regards the average infestation over the whole season, however, differences of 1·9 are significant.

From a consideration of the degree of control obtained over the whole season it is clear that the later spraying gave a better result than the earlier spraying and that the result given by a combination of the two was better still.

With regard to the degree of control evident at different periods during the picking season, it is clear that the earlier spraying (A) and the combination of early and late sprays (B) were equally good up to the third sampling (29th June). The efficiency of the former then fell off rapidly and was rather poor in the last half of the season. The late spray (C) was, throughout, practically as good as the two applications ; it was somewhat less effective only at the beginning of picking, entirely as a result of the lateness of application already referred to.

At the concentrations used no differences can be detected between the performances of Derris (C) and of Cubé (D) either at any one time during the picking season or for the whole period.

Loganberries—Time of Application.

Objects. This trial was carried out to determine (a) whether the early (mid-June) spraying is necessary and (b) whether an additional spraying (shortly before picking begins) would increase the degree of control obtained, especially as regards the later pickings of fruit.

Layout. Four rows of loganberries each consisting of fifteen bushes were used for this trial. A type of layout suitable for the comparison of three different treatments, and which had proved satisfactory in two previous seasons, was again adopted. The details of this are shown in a plan given in the previous paper of this series (6).

Unsprayed plots were omitted from the general scheme, since the object of the trial was not to determine whether the pest could be controlled, but to compare the relative merits of three good methods of controlling it. At one end of the plantation two plots of three bushes each were left unsprayed, mainly to compare the natural infestation with that of previous seasons.

The three treatments were as follows :

1. Twice sprayed (6th and 13th June).
2. Once sprayed (13th June).
3. Twice sprayed (13th and 21st June).

Application. The first spraying (6th June) was given three days after hatching was first observed and was approximately equivalent to the mid-June application of a normal season.

The second spraying (13th June) was given when the larvae were first observed to feed to any extent on the fruits and was thus equivalent to the late June application of a normal season.

The third spraying (21st June) occurred nine days before loganberry picking began.

Results. The results are shown in Table III.

TABLE III.

LOGANBERRY SPRAYING TRIAL.

Percentage of Infested Fruits.

Date of Sampling.	Sprayed with Derris and Soap.			Neighbouring unsprayed bushes.
	Twice, 6th and 13th June.	Once, 13th June.	Twice, 13th and 21st June.	
30th June	3·3	7·0	5·0	48·0
6th July	3·0	7·7	3·3	74·0
11th July	3·7	3·0	0·7	66·0
16th July	2·7	6·0	1·3	65·0
23rd July	5·7	7·0	2·0	44·0
30th July	8·7	16·7	3·3	46·0
Average of six pickings	4·5	7·9	2·6	57·2

Analysis of Sprayed Treatments.

	General Mean.	Standard Error.	Significant Difference.
Individual pickings	5·0	1·4	**4·0**
Six pickings	5·0	0·6	**1·6**

As was anticipated, the omission of the first spraying did not much affect the result. The degree of control given by a single spray (13th June) applied when larval damage to the fruit became noticeable was not appreciably improved by an extra spray applied a week earlier (6th June) when hatching began.

It is clear that, of the two sprayings hitherto thought desirable, the second is the important one and *by itself gives highly satisfactory results.*

A very late spray (21st June)—only nine days before picking began—gave a further slight improvement, at any rate as regards the later pickings, but commercially speaking its application was scarcely justified.

The unsprayed plots showed that the infestation was very much lower than in 1932 (57·2 as compared with 93·9 per cent.), a fact which seems to have been of general occurrence elsewhere.

The figures from these unsprayed plots could not, of course, be included in the analysis of the results, but, since previous experience has shown that very little variation in intensity of attack occurs on this plantation, comparison can fairly be made with the sprayed plots. Such a comparison shows that the degree of control obtained with any of the treatments was much better than that obtained in 1932.

Loganberries—Use of Gelatine.

Objects. To determine whether the addition of gelatine to the Derris and soap spray would improve the degree of control obtained in the later pickings of fruit.

Layout. The eight rows of loganberries used for this trial were divided into eight plots of twelve bushes each, four plots to each of the two spray treatments tested.

Half the plots received the normal spray of 2 lb. Derris, 5 lb. soap and 100 gallons water; this was used as a standard of comparison. The remaining plots received a

similar spray to which, however, commercial spray gelatine was added at the rate of 2 lb. per 100 gallons.

One spraying only was given (14th June) a few days after larvae were first observed feeding on the green fruits.

Results. Random samples of berries taken on five occasions during the picking season revealed no differences between the two treatments, the figures for the whole season (averages of five samplings) being as follows :

With added gelatine	6·3 per cent. infested.
Without gelatine	6·8 per cent. infested.

It seems unnecessary to give the detailed figures of individual pickings, since these show the same similarity between the treatments.

Blackberries.

Objects. Preliminary information obtained in 1932 (6) showed that the pest can be controlled on blackberries by means of Derris and soap applied to kill the larvae.

The small scale experiments carried out on blackberries in 1933 were designed (a) to confirm the previous season's results and (b) to gain further information as to the number of sprays necessary and the optimum time of application.

Layout. The blackberries were available only in groups of three adjacent bushes. Accordingly each group was treated as a separate small trial and in each case two bushes were sprayed and one left unsprayed as a " control ".

The dates of spraying and the results (as shown by random samples of fruit) are given in Table IV.

TABLE IV.

EFFECT OF SPRAYING BLACKBERRIES WITH DERRIS AND SOAP.

	Dates of Spraying.	Per cent. infested berries.	
		Sprayed.	Unsprayed.
King's Acre Berry ..	13th June	4·6	80·7
Himalaya Berry ..	27th June and 8th July	2·6	51·2
Himalaya Berry ..	27th June	9·5	63·5
Himalaya Berry ..	8th July	4·5	55·4
" Cutleaf " Berry ..	8th July	0·9	20·5
Edward Langley ..	27th June	1·5	11·0

Results. The early variety, King's Acre Berry, again proved amenable to the same spray treatment as the loganberry. A single spraying given when the larvae began to attack the fruit (the same time as on loganberries) gave practically a complete control.

The results obtained on the Himalaya Berry are also highly satisfactory and suggest that a single application (made about two weeks after loganberries and raspberries are sprayed) will give adequate protection to the fruit.

Similar small trials were also carried out on the following varieties :

Lucretia.
Wilson Junior.
Blowers.
Youngberry.

These were all sprayed on 13th June but the bushes were very small and produced insufficient fruit to enable the infestation to be assessed by means of random samples. It was evident, however, that the quality of such fruit as they did produce was much improved as a result of spraying.

Conclusions and Recommendations.

Derris Dusting. Good results have been obtained by dusting three times with a Derris dust of 0·09 per cent. rotenone content applied to kill the beetle larvae (5, 6). This method of control is somewhat less effective than a single wet spraying given when the larvae begin to attack the fruit, it is more costly, and the dust is very apt to leave an unsightly (though harmless) deposit on the earlier berries. On the other hand a dust is quickly and easily applied and for this reason recommends itself to a great many growers.

An attempt to kill the adults—and so prevent egg laying and subsequent fruit damage—by means of a single application of dust was not successful. This experiment cannot, however, be regarded as conclusive in view of the good results obtained by Petherbridge and Thomas (3) who dusted loganberries in a similar manner. To get adequate control by means of a dust applied sufficiently early to avoid leaving a deposit on the fruit, and intended for the adult beetles rather than the larvae, it may be necessary to dust very heavily and to use a dust of higher rotenone content than that hitherto used in our experiments.

In the light of our present knowledge it may be suggested that, *where it is preferred to wet spraying,* dusting should be carried out during (in a normal season) the first half of June. For preference more than one dusting should be given. Dusting early in June—about the beginning of flowering—should kill many of the adults and so prevent a good deal of egg-laying. A further dusting about the middle of the month will coincide with the peak period of egg-laying and should thus affect both the ovipositing adults and the larvae which subsequently hatch out from such eggs as are laid.

Dusting should be carried out during absolutely calm weather, since even a slight breeze makes efficient and economical dusting impossible.

Wet Spraying with Derris. From the results of field spraying trials carried out to date at East Malling it is clear that *one application* of Derris and soap is adequate for either raspberries or loganberries. This should be given when the larvae begin to damage the berries. On raspberries this may be reckoned as about three weeks and on loganberries as practically four weeks after the beginning of blossoming. A convenient pointer to this period is the time when the earliest fruits of the raspberry Lloyd George turn red. This is, in south-eastern England, usually during the last week of June.

A pleasing feature of the 1933 trials is the discovery that a good deal of latitude may be allowed in timing the spray, especially on raspberries. On *raspberries* satisfactory results can be obtained by spraying at any time during (in a normal season) the latter half of June. Reasonably clean fruit can still be obtained if spraying is delayed even till the beginning of picking, without damage to the fruit either as spray injury or as an unsightly deposit.

If, to ensure maximum cleanliness of the late berries, two sprayings are preferred for *loganberries,* then the first should be given just before, or about the same time as, the raspberries are sprayed. The second should follow after a further week or ten days and will in practice be given a week or ten days before picking begins. In the past season's loganberry trials the pest proved unusually easy to control, a single spraying carried out on 13th June reducing an infestation of 57 to 8 per cent. In such circumstances little

was gained by an extra spraying on 21st June, which further reduced the attack to 3 per cent.

The results obtained on *blackberries* suggest that the very early varieties can be given exactly the same treatment as loganberries. For the chief commercial varieties, Himalaya Berry and Cutleaf Berry, one spraying appears to be adequate. The best time for this spraying is probably about a fortnight after the loganberries are sprayed. Further field confirmation of the 1933 results is required before growers can be definitely recommended to depart from the schedule hitherto recommended for blackberries, viz. spraying during the first and again during the second week of July.

Acknowledgments.

The continuation of this work has been made possible by funds provided by the Kent Branch of the National Farmers' Union, Messrs. Cooper, McDougall & Robertson, Ltd., the Agricultural Research Council and various private individuals.

The writer is again greatly indebted to Dr. Tattersfield of the Rothamsted Department of Insecticides and Fungicides, whose analyses and advice determined the rates of dilution of the Derris and Cubé used in these trials.

Thanks are also due to Mr. T. N. Hoblyn for valued assistance in planning the layout of the trials, and to him and Miss Joyce Edgar for statistical analyses of the results.

Summary.

1. Once more a spray containing sufficient finely ground Derris to give a rotenone content of 0·005 (approximately) per cent., and 5 lb. of soft soap per 100 gallons proved highly toxic to the larvae of the Raspberry and Loganberry Beetle.

2. The 1933 trials show that satisfactory results can be obtained both on raspberries and on loganberries with one spraying, given when the larvae begin to attack the berries (normally towards the end of June).

3. Great latitude can be allowed in timing the spray, especially on raspberries, and the margin of safety is large.

4. On loganberries it was found that the effectiveness of control measures can be improved as regards the later pickings of fruit by giving an additional spraying shortly before picking begins.

5. Inconclusive results were obtained in an experiment on raspberries designed to test the value of a Derris dust containing 0·1 per cent. rotenone for use against the adult beetle.

6. Further small trials on various varieties confirmed last season's finding that the pest can be controlled on cultivated blackberries by means of Derris and soap, and suggested that for these crops also a single spraying may prove adequate.

References.

(1) Kearns, H. G. H. and Walton, C. L. Journ. Pom. and Hort. Sci., 1933, **11**, 39-52.

(2) Parker, T. Fruitgrower, 1933, **75**, No. 1941, 299-301.

(3) Petherbridge, F. R. and Thomas, I. Journ. Min. of Agric., 1933, **39**, 1017-28.

(4) Steer, W. E. Malling Res. Sta. Ann. Rep. for 1928-30, II. (Supplement) (1931), 210-21.

(5) ———— Journ. Pom. and Hort. Sci., 1932, **10**, 1-16.

(6) ———— Journ. Pom. and Hort. Sci., 1933, **11**, 19-38.

EXPERIMENTS ON THE CONTROL OF THE APPLE SAWFLY *(HOPLOCAMPA TESTUDINEA* KLUG.)

THE RESULTS OF ONE SEASON'S FIELD TRIALS AND SOME CONSIDERATIONS ARISING FROM THEM

By G. L. HEY and W. STEER

INTRODUCTION.

The work described in this paper is the outcome of the collaboration of the two authors who approached the subject from different points of view. W. Steer, with the help of funds provided by the Kent Branch of the National Farmers' Union, Messrs. Cooper, McDougall & Robertson Ltd., the Agricultural Research Council and various private individuals, was engaged in trials of Derris as an insecticide. G. L. Hey by means of a grant from Imperial Chemical Industries Ltd., was studying a number of new insecticides and wetting-out agents in relation to pest control, whilst the other substances used were of common interest as standards of comparison. In view of the similarity of the two sets of problems the mutual advantages of carrying out joint field trials and of close collaboration throughout the work were not to be neglected.

Object and Scope of the Experiments.

The experiments on Apple Sawfly control carried out in 1933 consisted partly of spraying and dusting trials and partly of observations on the habits of the pest. The chief objects in view were to ascertain the degree of control obtainable with certain sprays and to throw light on the vulnerability of sawfly at various stages in its development.

The information obtained shows the relative value of directing control measures against

1. The adults—by means of Derris.
2. The eggs—by means of nicotine.
3. The young larvae—by means of (*a*) petal fall applications of Derris, barium silicofluoride and lead arsenate, and (*b*) post petal fall applications of Derris, barium silicofluoride, lead arsenate and nicotine.
4. The migrating larvae—by means of Derris and nicotine.

Spray Materials.

The chief materials used and their concentrations were as follows :

Derris	2 lb. per 100 gallons.
Nicotine (95-98 per cent.)	8 oz. per 100 gallons.
Lead arsenate paste	4 lb. per 100 gallons.
Barium silicofluoride preparation ..	4 lb. per 100 gallons.

The Derris used* contained 2·71 per cent. rotenone (in terms of crude rotenone); as used in the field the spray thus had a rotenone content of 0·005 per cent.

The barium preparation contained 20 per cent. talc and 80 per cent. barium silicofluoride.

Except where otherwise stated the Derris and the nicotine sprays contained 8 lb. of soft soap, and the lead arsenate and the barium sprays contained 2 lb. of gelatine per 100 gallons. In some of the experiments Agral I was used as a wetter and spreader for nicotine and for barium silicofluoride.

The Derris dust was composed of 10 per cent. of the Derris described above and 90 per cent. of China clay, and thus contained 0·27 per cent. rotenone. It was mixed in a small electrically driven mixing machine.

Spraying Technique.

The Derris dust (Trials IX, X) was applied with a two-wheeled hand-operated machine, and each application was made in the early morning to ensure optimum dusting conditions.

In the majority of the spraying trials the washes were applied by means of a 2½ h.p. machine supplying two nozzles at a pressure of 200 lb.

The Lane's (Trial VI) were sprayed with a hand operated machine supplying one nozzle at 150-200 lb. pressure.

The Court Pendu trees (Trial VII) were sprayed during the course of the Station's routine spraying operations by means of a 10 h.p. machine supplying eight nozzles at a pressure of 350 lb. This machine was also used in Trial VIII (Cox).

The Worcesters in Trial I (the only trial conducted on an outside farm) were sprayed by means of a 10 h.p. machine supplying four nozzles at a pressure of 400 lb.

The sprays and dusts were all applied under satisfactory weather conditions. In most cases the weather following application was also satisfactory, the few exceptions being commented on in their proper context. In spraying, the trees were drenched to ensure wetting both the calyx cup and the surface of the fruitlets.

The term "petal fall" is here taken to mean when about 80 per cent. of the petals have fallen and when most of the remainder fall readily when the tree is shaken slightly. The term "post petal fall" has for the sake of brevity been used in reference to sprays applied about seven days after petal fall (hitherto regarded as the optimum time for nicotine spraying, on the hypothesis that a majority of the larvae are then accessible).

Recording of Results.

In each trial complete records were kept of the drops, thinnings, windfalls and picked crop.

The drops may be defined as all the fruitlets which fell, from the very first and smallest (falling soon after petal fall) to the half-grown apples of the normal June-July drop. They were picked up and counted at frequent intervals and the number damaged by sawfly was noted.

Thinning was practised only in Trials III, IV and IX, where it was carried out 20th-22nd June. The thinnings were recorded in the same manner as the drops and are reckoned as such in this report.

The windfalls—fully developed apples which fell shortly before picking time—were treated as part of the crop.

* For further particulars of this Derris sample see Steer, W., "Studies on *Eriocampoides limacina* Retz. Fabr.—IV," *East Malling Res. Sta. Ann. Rep. for* 1933 (1934), p. 188.

In dealing with the crop the clean and sawfly damaged fruits were recorded both by number and by weight. Since it seemed unnecessary to make use of both sets of data, the weight records have not, except in one instance, been employed in this report.

Recording was facilitated by the use of small mechanical hand counting machines, which enable fruit counts to be made with great speed and accuracy.

The tables show the total number and the percentage damaged of both the drops and the picked crop. The column "Total Sawfly damage %" represents the total number of sawfly damaged apples (drops and crop together) as a percentage of the "total set", the total set being the number of drops and picked fruits added together.

THE 1933 FIELD TRIALS.

The biological notes given in the following pages are abstracted from our field notes and are of great assistance in the interpretation of the results of the trials.

In the descriptions of the trials attention is in each case drawn to the main points of the short tables of results, but further comment is reserved till the discussion (pp. 207-215) where the whole series of trials is reviewed under appropriate headings.

Trial I—Worcester.

Object. To determine the relative values of Derris, nicotine, lead arsenate and barium silicofluoride applied about a week after petal fall.

Layout. The plantation was divided into twenty plots arranged in four blocks of five. The treatments were arranged at random within each block. Each plot contained nine trees, but of these only the three centre ones were used for record purposes, the layout being such that these three indicator trees were in all cases protected by guard rows from neighbouring treatments.

The plan of one of the four blocks is shown in Fig. 1, where the circles represent "indicator" trees and the letters A, B, C, D, E the five treatments.

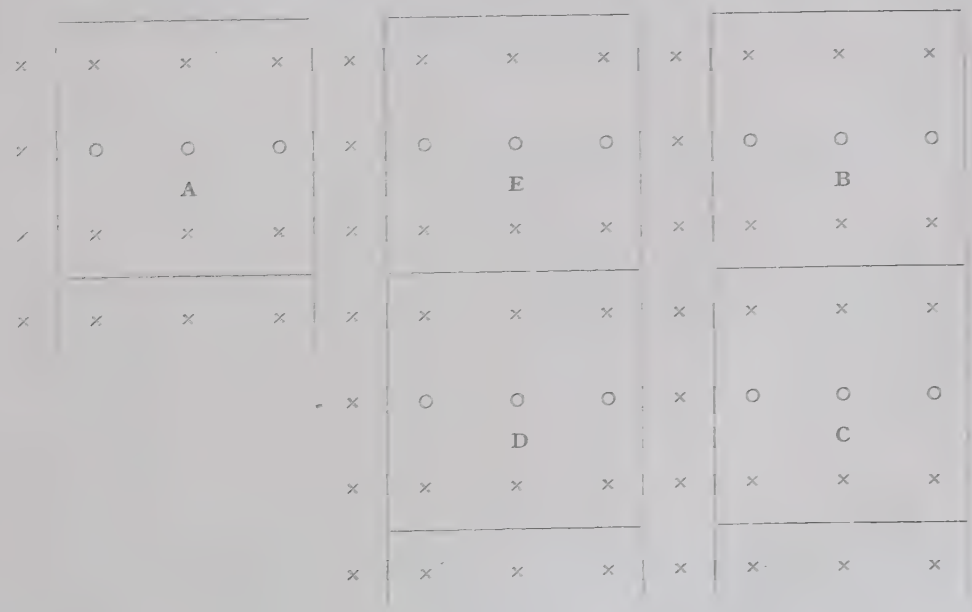


Fig. 1.

Biological Notes.

Full bloom 4th May. Petal fall 11th May.

Sprays applied 17th May. Hatching began 19th May and was complete by 24th May. Thus the sprays were applied *just before the beginning of hatching.*

Table I.

Trial I. Worcester.

Twelve trees per treatment recorded.

Treatment.	Drops.		Crop.		Total Sawfly damage. %	% Reduction.
	Total No.	% Infested.	Total No.	% Scarred.		
Control	6,333	69·5	1,620	6·2	**56·6**	—
Nicotine and Soap ..	4,320	23·6	4,828	3·4	**12·7**	78
Derris and Soap ..	4,460	41·9	3,539	4·1	**27·1**	52
Lead and Gelatine ..	4,754	56·2	2,070	6·5	**40·9**	28
Barium and Gelatine	4,316	49·1	1,763	10·7	**39·3**	29

Results. It will be seen from Table I that nicotine and soap, although applied before any hatching began, gave very good control. Derris reduced the infestation by half, but lead arsenate and barium silicofluoride were each much less effective.

Trial II—Worcester.

Objects. 1. To test the effect of applying barium silicofluoride a week after petal fall.

2. To ascertain the relative values of Agral I and gelatine when used with barium silicofluoride.

Layout. Fig. 2 shows the type of layout adopted in Trials II to V, which were each conducted on four rows of eight trees, interplanted with trees of another variety.

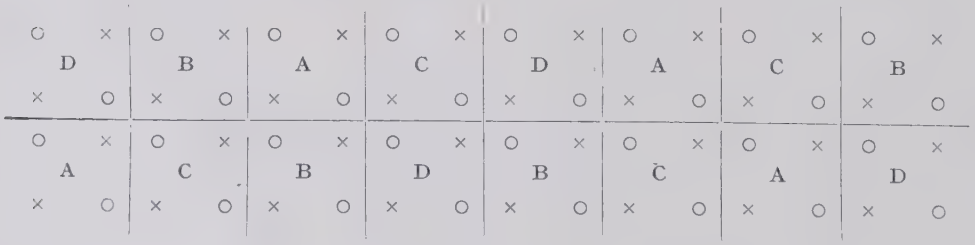


Fig. 2.

The crosses represent trees used in the experiment and the circles represent trees of another variety, used merely as unsprayed " buffers ". A, B, C, and D are four treatments (including unsprayed controls).

Biological Notes.

Full bloom 2nd May. Petal fall 11th May.

Sprays applied on 18th May, when most of the eggs were hatching but before the larvae had moved from the eggs and before any penetration had occurred.

By 20th May a few larvae had penetrated. By 24th May hatching was over, tunnelling was extensive and some tunnels were cracking.

Table II.

Trial II. Worcester.

Eight trees per treatment.

Treatment.	Drops.		Crop.		Total Sawfly damage. %	% Reduction.
	Total No.	% Infested.	Total No.	% Scarred.		
Control	1,529	53·9	2,799	22·6	**34·3**	—
Barium (4 lb.), Agral I (5 lb.), Gelatine (2 lb.)	1,601	35·4	3,689	21·6	**26·2**	24
Barium (4 lb.), Agral I (5 lb.)	1,570	42·5	3,479	18·4	**24·8**	28
Barium (4 lb.), Gelatine (2 lb.)	2,872	33·7	3,629	21·2	**24·1**	30

Results. It is clear that barium silicofluoride gave the same measure of control here as in Trial I, and that its value was not increased by adding 5 lb. of Agral I either in place of or in addition to 2 lb. of commercial spray gelatine.

Trial III—James Grieve.

Object. To ascertain the relative values of:

1. Derris at petal fall.
2. Derris a week after petal fall, and
3. Nicotine a week after petal fall (hitherto a standard recommendation), with a view to combining Derris with the first post blossom scab spray, either as a true petal fall or as a delayed petal fall spray.

Layout. See Trial II.

Biological Notes.

Full bloom 1st May. Petal fall 11th May.

Series A sprayed with Derris and lime-sulphur and remaining trees with lime-sulphur (1 in 120) only, on 12th May. No hatching observed by 17th May. Series C and D sprayed 18th May, when most of the eggs were hatching and a few larvae had begun to penetrate. Hatching complete and most of larvae penetrated by 25th May.

TABLE III.

TRIAL III. J. GRIEVE.

Eight trees per treatment in all except B which had seven.

Treatment.	Drops.		Crop.		Total Sawfly damage. %	% Reduction.
	Total No.	% Infested.	Total No.	% Scarred.		
A Derris, 12th May ..	14,159	41·6	5,720	1·2	**30·2**	—
B Control—not sprayed ..	18,412	39·0	5,247	1·8	**31·0**	—
C Nicotine and Soap, 18th May ..	16,109	17·7	6,322	3·3	**13·3**	57
D Derris and Soap, 18th May ..	23,217	17·3	7,396	4·1	**14·0**	55

Results. Although Derris (with lime-sulphur) had no effect as a petal fall spray, it gave the same measure of control as nicotine when used (with soap) seven days after petal fall.

Trial IV—James Grieve.

Object. To compare Agral I with soap as a wetter for nicotine.

Layout. See Trial II.

BIOLOGICAL NOTES.

Full bloom 1st May. Petal fall 11th May.

Hatching began 17th-18th May. Penetration of fruits began 18th May.

Sprays applied 20th May, when most of larvae had hatched out and just penetrated the fruits. Penetration complete and tunnels beginning to crack by 24th May.

TABLE IV.

TRIAL IV. J. GRIEVE.

Eight trees per treatment; the figures in brackets are lb. per 100 gallons.

Treatment.	Drops.		Crop.		Total Sawfly damage. %	% Reduction.
	Total No.	% Infested.	Total No.	% Scarred.		
Control	8,451	18·9	4,905	5·8	**14·3**	—
Nicotine and Soap (8 lb.)	8,294	8·8	4,733	5·6	**7·4**	48
Nicotine and Agral I ($2\frac{1}{2}$ lb.)	7,277	8·6	4,718	6·6	**7·9**	45
Nicotine and Agral I (5 lb.)	6,150	9·0	4,186	6·0	**7·4**	48

Results. Judging from the controls the infestation was, unfortunately, very low. Nevertheless it is clear that the three sprays were of equal value.

Trial V—Annie Elizabeth.

Objects. 1. To compare Agral I with soap as a wetter for nicotine.
2. To compare Nictagral B with nicotine and soap and with nicotine and Agral I on an equivalent nicotine basis.

Layout. See Trial II.

Biological Notes.

Full bloom 7th-8th May. Petal fall 14th May.
Hatching began 18th May. Sprays applied 20th May, when most of the larvae had hatched but not yet moved from the eggs. Penetration began 23rd May. Hatching finished, penetration complete and some tunnels cracking on 24th May.

Table V.

Trial V. Annie Elizabeth.

Treatment.	Drops.		Crop.		Total Sawfly damage. %	% Reduction.
	Total No.	% Infested.	Total No.	% Scarred.		
Control—8 trees ..	955	69·2	1,177	23·1	**43·5**	—
Nicotine and Soap (8 lb.)—7 trees ..	386	26·5	1,349	15·6	**17·9**	59
Nicotine and Agral I (2½ lb.)—8 trees ..	631	26·0	1,759	16·4	**19·1**	56
Nictagral B, 1 in 300—7 trees	564	23·9	1,486	15·7	**17·9**	59

Results. The three sprays were obviously of equal value.

Trial VI—Lane's.

Objects. To compare (1) the relative values of lead arsenate, barium silicofluoride, Derris and nicotine, and (2) early and later applications of lead arsenate, barium silicofluoride and Derris.

Layout. There were four blocks of nine trees each, and the nine treatments were arranged at random in each block.

Biological Notes.

Full bloom 4th May. Petal fall 13th-14th May.
Petal fall sprays 14th May. Hatching began 18th May.
Post petal fall sprays 21st May, when about 50 per cent. of the eggs had hatched, some fruits were penetrated, but most of larvae not yet moved away from the eggs.

TABLE VI.

TRIAL VI. LANE'S.

Four trees per treatment.

Treatment.	DROPS.		CROP.		Total Sawfly damage. %	% Reduction.
	Total No.	% Infested.	Total No.	% Scarred.		
Control—not sprayed ..	1,765	53·4	1,035	2·0	**32·1**	—
Lead Arsenate } on	1,250	56·2	1,187	2·6	**29·0**	10
Derris } 14th	629	9·4	1,070	0·9	**3·2**	90
Barium } May	1,383	40·3	900	2·8	**23·9**	22
Lead Arsenate }	1,291	46·8	1,329	2·0	**19·9**	38
Derris } on	1,052	16·2	1,651	5·5	**8·3**	74
Barium } 21st	1,261	47·3	1,008	4·1	**26·1**	19
Nicotine } May	1,459	26·6	1,766	4·5	**11·9**	63
Derris and Gelatine	907	34·5	1,294	5·6	**16·2**	49

Results. Derris was the only effective petal fall spray. As post petal fall sprays nicotine and Derris (each with soap) were about equal. Derris was apparently less effective with gelatine than with soap, whilst barium silicofluoride and lead arsenate as either petal fall or post petal fall sprays were still less effective.

Trial VII—Court Pendu Plat.

Object. Small trial undertaken to determine whether nicotine affects the eggs of sawfly.

Layout. Four trees only, in a plantation of mixed varieties. Three trees sprayed and one left unsprayed.

BIOLOGICAL NOTES.

Full bloom 17th May. Petal fall?

Adults ovipositing and very many eggs found in blossoms on 19th May. Spray applied 20th May. Hatching began 26th May. A few fruits tunnelled, most of larvae just hatched but not moved from egg, and a few unhatched eggs on 29th May. Penetration complete by 1st June.

TABLE VII.

TRIAL VII. COURT PENDU PLAT.

Treatment.	DROPS.		CROP.		Total Sawfly damage. %	% Reduction.
	Total No.	% Infested.	Total No.	% Scarred.		
Control—1 tree ..	64	71·9	139	7·2	**27·6**	—
Nicotine—3 trees ..	230	16·5	823	2·2	**5·2**	81

Results. This trial, although on a very small scale, shows that nicotine and soap *applied six days before hatching began*, gave a very high measure of control.

Trial VIII—Cox.

Object. This trial was primarily concerned with Apple Scab; Sawfly control (through the addition of nicotine or Derris to the petal fall spray) was merely incidental. We are indebted to Mr. M. H. Moore* for permission to make use of the figures he obtained.

Layout. The whole plantation of ten rows of Cox was sprayed at petal fall with lime sulphur and sulphite lye (6 pints of each per 100 gallons). On one half nicotine was added to the spray and on the other half Derris. A few trees at each extremity of the plot were left entirely unsprayed. The layout was on rather different lines from that of the other trials described here and this fact should be borne in mind in drawing comparisons.

Biological Notes.

Full bloom 1st May. Petal fall 13th May.

Sprays applied 15th May. Hatching had not begun on 19th May. Thus the sprays were applied at least four days before the beginning of hatching.

Table VIII.

Trial VIII. Cox.

Treatment.	Drops.		Crop.		Total Sawfly damage. %	% Reduction.
	Total No.	% Infested.	Total No.	% Scarred.		
Control (15 trees) ..	3,293	51·2	2,037	4·1	**30·1**	—
Nicotine (72 trees) ..	20,018	10·9	25,754	0·5	**4·8**	84
Derris (71 trees) ..	17,399	32·9	19,082	1·2	**16·8**	44

Results. A commercially complete control of sawfly was obtained by adding nicotine to the lime-sulphur Scab spray, applied at petal fall well before hatching began. Derris was, in this trial, much less effective.

Trial IX—Early Victoria.

Object. To prevent or lessen secondary infestation by control of the migrating larvae, using a Derris dust, Derris and soap and nicotine and soap.

Layout. This trial was carried out on a few scattered trees in four rows of Early Victoria. The trees were fairly comparable as regards blossom production and suitability for migration.

Biological Notes.

Full bloom 1st May. Petal fall 12th May.

Dust and sprays applied 30th May, but the presence of holes in the sides of many of the fruitlets showed that some migration had already taken place. Several dead larvae were found on fruits of treated, but not control, trees on 1st June. These were instars I and II. A series of fruitlets picked on 30th May and subsequently examined contained instars II and III, II predominating.

* We are also indebted to Mr. Moore for much helpful criticism in the production of this report.

TABLE IX.

TRIAL IX. EARLY VICTORIA.

Treatment.	DROPS.		CROP.		Total Sawfly damage. %	% Reduction.
	Total No.	% Infested.	Total No.	% Scarred.		
Control—3 trees ..	9,630	26·6	3,096	1·5	**20·3**	—
Derris dust, 30th May—2 trees	4,871	16·4	1,733	3·6	**13·0**	36
Derris and Soap, 30th May—2 trees ..	4,264	20·4	1,894	3·7	**14·4**	29
Nicotine and Soap, 30th May—2 trees ..	4,854	15·6	2,079	1·9	**10·9**	47

Results. Table IX shows that each treatment reduced the sawfly infestation by about a third, although it was clear when the dust and sprays were applied that a good deal of migration had already taken place.

Daily records of the progress of migration between 30th May and 18th June (after which date no further migration occurred) confirm these results. On marked branches kept under observation the number of apples attacked increased during this period by the following amounts *:

Controls	72·5%
Derris dust	5·2%
Derris and soap	43·0%
Nicotine and soap	26·0%

From this it would appear that the dust was superior to the wet sprays as a means of arresting migration.

Trial X—Lane's.

Object. To test the value of a Derris dust of known rotenone content, applied at

1. Full bloom, to kill ovipositing adults,
2. Petal fall, to kill subsequently hatched larvae, and
3. A week after petal fall, to kill hatched and hatching larvae.

Layout. The plantation was divided into four blocks of eleven trees each. The blocks, each of which received a different treatment, were separated by buffer rows.

BIOLOGICAL NOTES.

Full bloom 4th May. Petal fall 14th May.

First dusting 5th May, estimated to be quite two days late since a few eggs had already been laid. Heavy rain fell two hours after dust applied. Rain recorded 5th May 0·15 ins., 6th May 0·61 ins., 7th May 0·12 ins.

Second dusting 15th May. Hatching began 18th May. Penetration of fruitlets began 21st May and complete by 27th May.

Third dusting 22nd May. Heavy rain recorded in evening of 23rd May (0·48 ins.), then no considerable amount till May 27th. The second and third dustings adhered well.

Used about 15 ozs. of dust per tree, the trees having an average height of 10 ft. and average spread of 14 ft.

* For further details of these records see Hey, G. L., and Steer, W., " Miscellaneous Observations on Apple Sawfly," *East Malling Res. Sta. Ann. Rep. for* 1933 (1934), p. 234.

TABLE X.

TRIAL X. LANE'S.

Five trees per treatment.

Treatment.	Drops.		Crop.		Total Sawfly damage. %	% Reduction.
	Total No.	% Infested.	Total No.	% Scarred.		
Control—not dusted	1,694	51·9	1,745	1·3	**25·0**	—
Dusted 5th May ..	1,969	32·4	2,088	0·7	**15·4**	38
Dusted 15th May ..	1,060	64·2	1,155	2·8	**31·7**	—
Dusted 22nd May ..	947	49·7	1,286	2·8	**22·2**	—

Results. Records were taken from the five central trees in each block. The only dusting which reduced the infestation was that of 5th May (full bloom).

DISCUSSION.

Vulnerability of the Adults. (Trial X.)

In Trial X a Derris dust was applied to the blossoms to prevent egg laying.

The only other recorded attempt to attack the pest in the adult stage appears to be that of Miles (9) who reduced an infestation of 24·9 to 7·0 per cent. by means of four applications of a naphthalene dust. The value of his dust no doubt lay in its deterrent effect—an opinion shared by Kearns (7) and by Miles himself. The method is therefore open to the objection that the sawflies would probably be driven off dusted plantations only to lay their eggs in adjacent untreated ones.

Moore (10) records a reduction of sawfly damage by means of " pink blossom " applications of either Bordeaux mixture or lime-sulphur (each with arsenate). The probable explanation is that advanced by Moore himself—a deterrent action on the adults. It is unlikely that the adults were poisoned (at any rate by the arsenate) through feeding on sprayed blossoms, since the " control " trees were themselves sprayed with lead arsenate. A further but rather remote possibility is that the combined spray had some undetermined effect on a later stage of the insect. Moore's results were obtained merely as an incidental effect of routine Scab sprays and there are, naturally, no biological observations which might be used to check these hypotheses.

Moore also refers to the fact that in 1932 sawfly damage was negligible on plots sprayed with nicotine and soap rather late in the " pink bud " stage. This spray by turning the petals brown may well have made the blossom unattractive to ovipositing adults.

Derris dust was used in our trial since it was expected to act not as a deterrent but as a contact insecticide on those sawflies which came into contact with it. Under laboratory conditions sawflies were killed by walking on dusted blossoms but were in no way deterred by the dust.

Table X shows that dusting at full bloom was only partially successful, reducing the infestation from 25 to 15 per cent. Account, however, should be taken of two factors which may have reduced the efficiency of the dust :

1. The application was delayed on account of adverse weather conditions till 5th May. At this date the trees were actually past full bloom and oviposition had already begun.

2. Within two hours of dusting heavy showers fell and continued all day, washing off a great deal of the dust.

In the circumstances it is surprising that the dust had any effect at all. Its use calls for further investigation.

The Vulnerability of the Eggs to Nicotine. (Trials I, VII, VIII.)

Previous workers are not in complete agreement with regard to the vulnerability of the egg stage.

Thus Petherbridge and Tunnington (11) regard spraying [with nicotine] as likely to be more efficacious if carried out soon after the larvae have hatched, and on this hypothesis they base their recommendations as to the use of nicotine.

Kearns and Swarbrick (4) state that " It is during the period between the larva hatching from the egg and the time when it disappears into the fruitlet that it is possible to obtain control of the pest."

In a later report (5) these writers, referring again to their 1931 investigations, state " By examination it was determined that the nicotine wash used had provided a control by killing recently hatched larvae and larvae just about to emerge from the eggs." In the same journal Kearns, Marsh and Pearce (6) say, " . . . the success of a control measure depends on killing the maximum number of nearly hatched or newly hatched larvae."

Miles (8) suggests that the nicotine applied by Petherbridge and Tunnington seven days after petal fall was successful because it could " penetrate into the calyx cup and reach exposed eggs and emerging larvae." In a later paper (9) he stresses the importance of timing a nicotine spray to catch hatching and migrating larvae.

Bush (2) says, " . . . the toxicity of a nicotine wash on the sawfly can only be effective on the hatching or hatched larvae. No control of unhatched eggs, unless the shell is already perforated by the efforts of the larvae to emerge, can be expected."

Kearns (7) is reported to regard as one of the most consistently vulnerable periods " the later portion of the incubative period of the eggs ".

Thus the general consensus of published opinion is that the larva (after hatching and before entering the fruit) is the most vulnerable stage, and that the egg is only vulnerable—if at all—just before or at the time of hatching.

Although in our experiments none of the nicotine sprays failed to reduce the infestation, it is important to note that those applied before any eggs hatched were much more effective than those applied after hatching began. Thus on Court Pendu Plat sprayed before petal fall the damage was reduced by 81 per cent., on Cox sprayed at petal fall it was reduced by 83 per cent. and on Worcester sprayed after petal fall but prior to egg hatch it was reduced by 78 per cent. On the other hand the efficiency of nicotine applied after the beginning of hatching was in no case greater than 63 per cent. There is no reason to suppose that the nicotine used in Trials I, VII and VIII was toxic to any but the egg stage. Moreover *the earlier portion of the incubative period of the egg was apparently just as vulnerable as the later portions.*

An examination of the published results of other workers suggests the susceptibility of the eggs to nicotine as a probable explanation of certain of their figures.

Thus Petherbridge and Tunnington (11) report that in 1927 the crop was doubled as a result of applying nicotine and soap to Worcesters " immediately following the drop of the petals ", when, presumably, only eggs would be present.

Kearns and Swarbrick (4) obtained good control on Worcesters in 1931 with nicotine applied at any time from three to eight days after petal fall, whereas the same

spray applied twelve days after petal fall gave poor results. Their " petal fall " is defined as " the period when the majority of the petals fell when the branches were subjected to a slight vibration by tapping upon them ", and is thus likely to be about two days earlier than our " petal fall ". Their latest spray may have been applied when penetration of the fruit by the larvae was well advanced and so failed materially to reduce the infestation, but it seems likely that, of their successful applications, at least the earlier ones were made before hatching began and so killed the eggs. In 1932 these workers (5) obtained better results with nicotine applied six days after than applied either seven or twelve days after petal fall. The three sprays reduced an infestation of 41·0 per cent. to 2·7, 11·7 and 10·6 per cent. respectively. In the absence of data on hatching definite conclusions cannot be drawn as to the probable effect of their several sprays on the eggs, but it is reasonable to suggest that the earlier and more effective spray acted more as an ovicide and less as a larvicide than either of the others.

These results give some support to our conclusion that nicotine is likely to be more effective applied against the egg than against the larvae.

Vulnerability of the Newly Hatched Larvae.

This aspect of sawfly control can best be discussed in relation to the effects of the several spray substances used in our trials : nicotine, Derris, lead arsenate and barium silicofluoride.

The Effect of Nicotine (Trials III, IV, V, VI). Hatching is usually protracted and may extend over so long a period that most of the larvae penetrate the fruits before the last eggs hatch. Now since nicotine is toxic to the eggs it is obviously difficult to determine how much of its usefulness as a post petal fall spray can be attributed to its ovicidal properties and how much to its effect on the larvae.

The larvae were the objective of all the nicotine sprays applied after the beginning of hatching, and the results obtained with such sprays can probably be attributed largely to the action of nicotine on the larvae. In every case, as the following table shows, the attack was reduced by about a half.

Variety.	*Time of Spraying.*	*Percentage Reduction of Attack.*
Annie Elizabeth	before penetration of fruits began	59
Lane's	when penetration was beginning	63
Jas. Grieve	when penetration had begun	57
Jas. Grieve	when penetration was well advanced	48

These results are very similar to those obtained by other workers who have applied nicotine about a week after petal fall. Petherbridge and Tunnington (11) reduced an infestation of 85-90 per cent. to about 30 per cent. Kearns, Marsh and Pearce (6) reduced an infestation of 80 per cent. to 35-46 per cent. Austin, Jary and Martin (1), who expressly state that they sprayed " on the day after the majority of the eggs hatched ", reduced an infestation of 27·9 to 14·9 per cent. Kearns and Swarbrick (4, 5), however, obtained rather better results. In one year they reduced an infestation of 54·8 per cent. to 6·6, 12·9 and 34·6 per cent. with nicotine applied at seven, eight and twelve days after petal fall respectively. In another year they reduced an infestation of 41·0 per cent. to 11·7 and 10·6 per cent. with nicotine applied at seven and twelve days after petal fall, respectively.

It is evident from our results that the degree of control obtained by using nicotine against the larvae was much less than that obtained by using the same spray against the

eggs. This need not imply resistance of the larvae to the action of nicotine so much as failure of the spray to reach the larvae. Those larvae which have hatched but not moved from the eggs when the spray is applied presumably offer no difficulty beyond the supposed one of wetting the calyx cup (8, 2). On the other hand those which have burrowed into the fruit (whether just under the skin or otherwise) are probably less easily killed.

The difficulty of killing larvae which have penetrated the fruit—and penetration begins almost as soon as hatching—has evidently been borne in mind by other workers.

Petherbridge and Tunnington (11) suggest that the larvae are most vulnerable soon after they hatch. Miles (8) and Kearns and Swarbrick (4) draw attention to the importance of applying control measures before the larvae penetrate the fruit. Kearns and Swarbrick (5) also state that the larvae are most easily killed by a penetrating contact wash when they are either within the calyx cup or just commencing to burrow beneath the calyx.

Bearing the protracted hatching period in mind Bush (2) regards the ideal time for spraying (if one application only is to be given) as the period when tunnelling larvae [newly] hatched larvae, hatching eggs and a few unhatched eggs are all present together.

Lastly, Kearns (7) regards the larvae as vulnerable (*a*) when newly hatched, prior to burrowing into the fruitlet, and (*b*) when tunnelling under the skin. He explains that the larva usually begins its attack on the fruitlet by burrowing deeply into the flesh for about a week ; it then moves to the surface and tunnels under the skin for a further few days and finally burrows deeply again. Thus it is not likely to be easily accessible during either of its deep burrowing periods.

The Effect of Derris (Trials I, III, VI, VIII, X). The larvae seem to show the same susceptibility to a Derris Wash as to nicotine, since, as post petal fall sprays, the performances of the two materials were about equal. *Nicotine was markedly superior to Derris only if applied before the beginning of hatching.*

Variety.	*Time of Spraying.*	*Percentage Reduction of of attack.*	
		Derris.	Nicotine.
Worcester	just prior to egg hatch	52	78
Lane's	when penetration of fruits beginning ..	74	63
Jas. Grieve	when penetration had begun	55	57

Other workers have found a similarity in the performances of Derris and of nicotine each applied a week after petal fall. Austin, Jary and Martin (1) reduced an infestation of 27·9 per cent. to 11·8 and 19·5 per cent. with two forms of Derris, and to 14·9 per cent. with nicotine. Kearns and Swarbrick (5) reduced an infestation of 41·0 per cent. to 9·2 and 15·1 per cent. with two forms of Derris and to 11·7 per cent. with nicotine.

Used at petal fall Derris gave contradictory results, as the following table shows :

Variety.	*Date and form of Petal fall Spray.*	*Percentage Reduction of Attack.*
Jas. Grieve	12th May, with lime-sulphur	Nil.
Lane's	14th May, with soap	90
Cox	15th May, with lime-sulphur and sulphite lye ..	44

These differences might be due to unequal penetration of the calyx as a result of (*a*) varietal differences in structure or (*b*) differences in wetting power of the various sprays, but the most likely explanation of the lack of control on Grieve is the influence

of weather conditions. Heavy rain (0·12 ins.) fell between the spraying of the Grieves on 12th May and the spraying of the Lane's on 14th May, but no further rain fell till 23rd May.

As a dust, Derris had no effect on Lane's when applied either at petal fall or a week later, whereas it gave marked results on Early Victoria when applied eighteen days after petal fall to control migrating larvae. On the Lane's the dust probably failed to reach the larvae, since a Derris and soap spray applied about the same times gave good results.

The Effect of Lead Arsenate (Trials I, VI). The presumed value of lead arsenate lies in its stomach poison action on the young larvae, in the form of a deposit either within the calyx or on the outside of the fruitlet.

In our experiments we failed to get any appreciable measure of control on Lane's with lead arsenate at petal fall, but obtained a partial control on both Lane's and Worcester by spraying a week later.

Grubb and Bagenal (3) reduced sawfly damage with lead arsenate (in combination with lime-sulphur) applied " immediately after the blossom fell ".

Petherbridge and Tunnington (11) failed in 1926 to reduce sawfly with lead arsenate (used alone) " before the last petals dropped ".

Moore (10) reduced the attack by adding lime-sulphur (1-100) or Bordeaux mixture to a petal fall lead arsenate spray, but got little if any control by using petal fall applications either of lead arsenate or lime-sulphur (1-150, with gelatine).

Kearns and Swarbrick (5) got a partial control on Worcester with a colloidal lead arsenate spray seven days after petal fall.

It seems clear from our own and from other workers' results that lead arsenate may reduce the attack if applied a week after petal fall but has little if any effect as a petal fall spray *except in combination with a fungicide.*

It is doubtful whether the larvae feed to any extent in the calyx. It follows, then, that an arsenical deposit in the calyx cup is of less value than a deposit on the sides of the fruitlet. A petal fall spray might leave an appreciable and persistent deposit in the calyx, but such deposit as it leaves on the sides of the fruitlet is probably lost or greatly attenuated before the larvae begin to feed. Lead arsenate then is more likely to leave an effective deposit on the sides of the fruitlet as a post petal fall spray (applied about the time of hatching) than as a petal fall spray proper.

However, a petal fall combination spray of lead arsenate with either lime-sulphur or Bordeaux mixture, is apparently more effective than one of lead arsenate alone. The improvement which follows the addition of a fungicide may be due to

1. Superior sticking properties of the mixture,
2. Toxic properties of the fungicide itself, or
3. *An effect on the sawfly egg.*

Action on the egg, an explanation already put forward by Moore (10), is in reasonable accordance with the facts. It is at least possible that some reaction product of the mixture (e.g. free arsenic) is able to penetrate the egg and kill the embryo larva feeding within it.

The Effect of Barium silicofluoride (Trials I, II, VI). This spray behaved in much the same manner as lead arsenate and in no case gave more than 20-30 per cent. control. It probably acted as a stomach poison against the larvae.

Vulnerability of the Migrating Larvae. (Trial IX.)

In Trial IX a Derris dust, Derris-soap and nicotine-soap applied eighteen days after petal fall, each reduced sawfly damage by about a third. This reduction can only

have been obtained by killing the migrating larvae (in this case instars I, II and III), and so arresting secondary infestation.

Although migration had already begun, no fully exposed larvae were found at the time of spraying. A few infested fruits had the hind ends of larvae protruding from them, and the sprays probably killed these partly exposed larvae. The nicotine may also have penetrated the holes in the sides of the fruits and, as the weather was hot, affected some of the larvae within them. The dust doubtless came into contact with the larvae when they crawled over the dusted fruits. With regard to the Derris and soap spray it is not clear whether it acted solely in the same way as the dust (by subsequent contact with the larvae) or whether it also penetrated the galleries and killed the more easily accessible of the larvae in the fruits.

Petherbridge and Tunnington (11), who obtained good control in 1928 with nicotine seven days after petal fall, obtained still further control with an additional spraying seven days later still. Our results suggest that their second spraying affected the migrating larvae.

Wetters and Spreaders. (Trials II, IV, V, VI.)

Used on Worcester (Trial II) with barium silicofluoride, Agral I at 5 lb. was equal to Gelatine at 2 lb. per 100 gallons of wash. No improvement followed the use of both these substances together.

Used on Grieve (Trial IV) with nicotine, Agral I either at $2\frac{1}{2}$ or 5 lb. per 100 gallons was equivalent to 8 lb. of soap per 100 gallons. On Annie Elizabeth also (Trial V) $2\frac{1}{2}$ lb. of Agral I was as effective as 8 lb. of soap.

On Annie Elizabeth (Trial V) Nictagral B at 1 in 300 was equivalent to 8 oz. of 95-98 per cent. nicotine plus either 8 lb. of soap or $2\frac{1}{2}$ lb. of Agral I per 100 gallons. Nictagral B is stated to contain 15 per cent. of 95 per cent. nicotine; thus the concentration of nicotine was the same in each spray.

On Lane's (Trial VI) 8 lb. of soap was apparently superior to 2 lb. of gelatine, used with Derris under comparable conditions.

The Effect of Sawfly Control on Yield.

Sawfly damaged fruits almost invariably drop. Those which remain on the tree as scarred fruits till picking time form usually but a small proportion of the crop. The greater part of the loss is represented by the proportion of apples which drop (and are thus lost to the crop) as a direct result of sawfly attack. This is shown graphically in Fig. 3.

The numbers of dropped and picked fruits in Trial I are expressed in Fig. 3 as percentages of the total set per treatment. The natural drop (an approximate though not necessarily complete measurement of which is afforded by the unshaded areas of the "drops" columns) was about the same throughout. Each of the spray treatments increased the crop by the amount by which it reduced the sawfly drop, the actual amount varying with the efficiency of the spray treatment.

The actual weights of fruit (all grades) picked was as follows:

From control plots	.. ..	271·8 lb.
From nicotine plots	.. ..	728·7 lb.
From Derris plots	.. ..	579·4 lb.
From lead plots	.. ..	339·5 lb.
From barium plots	.. ..	286·0 lb.

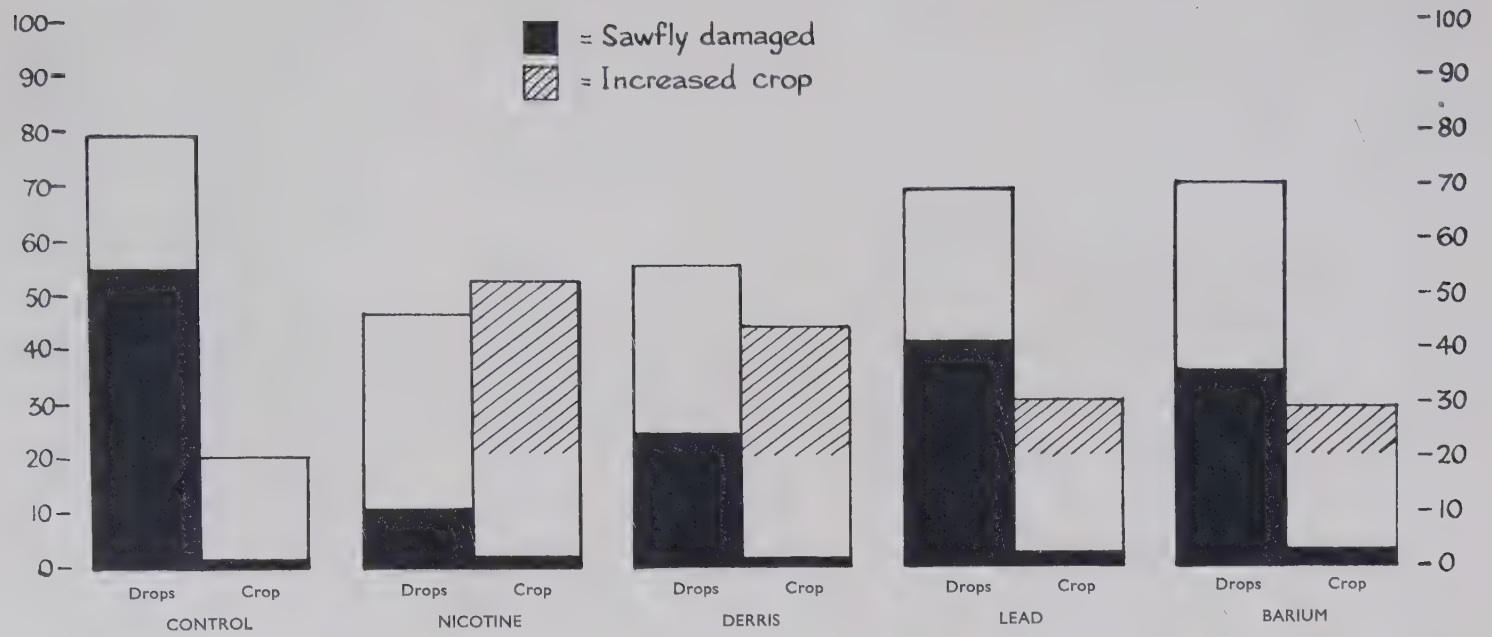


FIG. 3.

Showing the amounts of dropped and picked fruits from five differently treated series of plots as percentages of the total set per treatment, together with their respective proportions of sawfly damaged fruits.

Since the total set varied from plot to plot, and since the cropping of some plots was possibly somewhat favoured by position, it is better to compare the yields by expressing the number of fruits picked as a percentage of the total set per treatment (Table XI).

TABLE XI.

TRIAL I. WORCESTER.

The effect of spraying on the yield.

Treatment.	Total Sawfly damage %	Number of Apples picked expressed as % of total set.	% increase in picked crop.
Controls	56·6	20·3	—
Nicotine	12·7	52·8	160·1
Derris	27·1	44·2	117·7
Lead Arsenate	40·9	30·3	49·3
Barium Silicofluoride ..	39·3	29·0	42·9

Thus even a slight reduction in the amount of damaged fruits resulted in a substantial increase in the picked crop.

In cases of lower initial infestation the effect of spray treatment has a less pronounced effect on the crop, a fact which can readily be ascertained from the fruit count figures given on earlier pages.

The heavier the attack the greater is the effect of spraying on the yield.

General Conclusions.

From the commercial point of view the most important aspect of these trials is *the effect of nicotine on the eggs of Apple Sawfly*.

The practical advantages of being able to spray *at petal fall or at any time during the week following* and to get good results with a single spraying are obvious. More time is available for spraying, since there is less need for the accurate timing hitherto thought essential. Nicotine can be added to the petal fall scab spray and so obviate the need for separate sprayings for sawfly and scab ; this would itself save expense and lengthen the time available for spraying.

If, to control sawfly, nicotine is incorporated in a petal fall scab spray it is highly probable that the trees would have to be well drenched, and the addition of a suitable wetter and spreader may prove essential. To avoid the risk of spray damage with such a drenching wash, weaker dilutions of the fungicide may prove necessary. Investigations on the efficiency against scab and on the liability of such drenching washes to cause spray injury are in progress, and preliminary results are reported elsewhere by Moore.*

That nicotine does not lose toxicity when added to a scab spray is indicated by the results of Trial VIII, where it was incorporated with lime-sulphur, and from the work of Austin, Jary and Martin (1) who mixed it (for use against sawfly larvae) with two different forms of Bordeaux mixture.

When used primarily against the larvae, nicotine and Derris were, at the concentrations used, of approximately equal value. In addition to killing those larvae with which

* Moore, M. H., " A Field Spraying Trial of Combined Fungicide-Contact Insecticide Sprays in 1933," *East Malling Res. Sta. Ann. Rep. for* 1933 (1934), p. 156.

it comes into contact, nicotine probably kills the unhatched eggs remaining at the time of spraying. On the other hand Derris is probably toxic only to the larvae, though its residual contact properties give it an advantage over nicotine which compensates for its presumed lack of ovicidal effect.

As a dust the scope of Derris appears to be restricted to its uses (*a*) as a means of preventing oviposition by killing the adults, and (*b*) as a means of arresting secondary infestation by migrating larvae. For the latter purpose Derris-soap and nicotine-soap sprays also seem effective.

Lead arsenate at petal fall appears useless for sawfly control except in combination with a fungicide. It gives a slight measure of control (and, as a result, a small but appreciable increase in yield) if applied immediately before or just when the larvae first attack the fruitlets. These facts should be taken into account when estimating the value of lead arsenate as a constituent of post blossom " omnibus " washes.

If nicotine is included in a petal fall " omnibus " wash, nothing will be gained, so far as sawfly control is concerned, by the further addition of lead arsenate.

Finally it should be borne in mind that this paper is the report of but a single season's experimental results. It remains to be seen whether further experience under different seasonal or local conditions will confirm or modify any of the conclusions drawn herein.

ACKNOWLEDGMENTS.

We are indebted to Mr. H. B. Weston of Rocks Farm, East Malling, for the use of his orchard and for facilities for carrying out Trial I ; to Dr. F. Tattersfield of the Rothamsted Department of Insecticides for analyses of the Derris used in certain of the Trials ; to Mr. T. N. Hoblyn for assistance in plot planning ; and to Mr. and Mrs. A. M. Massee, who helped to count the drops in some of the trials. We are also grateful to Dr. R. C. Knight for valuable criticisms and suggestions, particularly as regards the form of this paper.

This work involved considerable disturbance of the routine operations of spraying, picking and marketing, and grateful thanks are due to several members of the staff, particularly Messrs. Amos, Moore and Painter, who cheerfully adjusted their organization to meet the special requirements of these experiments.

SUMMARY.

An account is given of field spraying trials carried out in 1933 and designed to compare the relative values of nicotine, Derris, lead arsenate and barium silicofluoride for use against the Apple Sawfly (*Hoplocampa testudinea* Klug.).

The results of these trials are discussed and the following conclusions are drawn as to the susceptibility of the several stages of the pest to the various sprays tested :

(*a*) *The adult* is susceptible to a Derris dust.

(*b*) *The egg* is (at any stage of its incubative period) susceptible to nicotine and soap—a fact of vast importance in commercial spray practice.

(*c*) *The newly hatched larva* appears to be equally susceptible to nicotine and to Derris (each with soap) at the concentrations used, but in the case of nicotine (applied a week after petal fall) it is difficult to differentiate exactly between an effect on the egg and an effect on the larva. Arsenate of lead and barium silicofluoride (each with gelatine) were of about equal value at the concentrations used, and were each much less efficient than nicotine.

(*d*) *The migrating larva.* Secondary infestation by migrating larvae, an important phase of sawfly attack, was arrested by a Derris dust, by Derris and soap and by nicotine and soap, each applied eighteen days after petal fall.

The performance of certain wetters and spreaders and the effect of sawfly control on yield are also briefly discussed.

REFERENCES.

(1) Austin, M. D., Jary, S. G. and Martin, H. "Some New Insecticides and Possible Insecticide-Fungicide Combinations." Hort. Educ. Assn. Year Book, 1932, **1**, 85-92.

(2) Bush, R. G. W. "Despise not Thine Enemy." Fruitgrower, 1933, **75**, 1041-2, 1045-6, **76**, 85-6, 90.

(3) Grubb, N. H. and Bagenal, N. B. "Fungicidal Spraying of Apples." E. Malling Res. Sta. Ann. Rep. for 1923 (1924), 120-4.

(4) Kearns, H. G. H. and Swarbrick, T. "Some Observations on the Control of the Apple Sawfly." Ann. Rep. Agric. and Hortic. Res. Sta., Long Ashton, 1931, 112-7.

(5) ——— "Further Observations on the Control of the Apple Sawfly." *Ibid.*, 1932, 90-4.

(6) Kearns, H. G. H., Marsh, R. W. and Pearce, T. J. P. "Experiments with Combined Insecticide-Fungicide Sprays for Apples." *Ibid.*, 1932, 66-85.

(7) Kearns, H. G. H. Paper on "Control of Apple Sawfly" given at the Imperial Fruit Show at Bristol on 2nd November, 1933, and reported in the Fruitgrower, 1933, **76**, 811-13.

(8) Miles, H. W. "On the Biology of the Apple Sawfly." Ann. App. Biol., 1932, **19**, 420-31.

(9) ——— "Dusting for the Control of Apple Sawfly: a Preliminary Experiment." Jour. Min. Agric., 1933, **39**, 1125-8.

(10) Moore, M. H. "Some Incidental Effects of Routine Scab-Sprays." E. Malling Res. Sta. Ann. Rep. for 1932 (1933), 90-8.

(11) Petherbridge, F. R. and Tunnington, F. "The Control of Apple Sawfly." Jour. Min. Agric., 1929, **35**, 1055-8.

AN EXPERIMENT ON THE CONTROL OF THE APPLE BLOSSOM WEEVIL (*ANTHONOMUS POMORUM* (L.) CURT.) BY MEANS OF A DERRIS DUST

By G. L. HEY, A. M. MASSEE and W. STEER

Object.

Laboratory observations showed that ground Derris root exerts a marked paralytic effect on Apple Blossom Weevils which come into contact with it by walking over the dusted surface of twigs. This fact suggested that a Derris dust applied to apple trees at a suitable time might prevent egg laying—either by killing or by paralysing the adult weevils—and so avoid subsequent blossom " capping ".

Layout.

A plantation of fourteen-year-old Lane's on mixed stocks was divided into eight blocks (each comprising eleven trees) separated by untreated buffer rows. The trees had an average height of 10 ft. and spread of 14 ft.

The treatments were each in duplicate and were :

1. One early dusting only ; 30th March.
2. One early and one later dusting ; 30th March and 7th April.
3. One later dusting only ; 7th April.
4. " Controls "—not dusted.

A subsidiary trial also was carried out on a three acre field of cordons (mixed Cox and Rival) through the courtesy of H. B. Weston, Esq. Here the early dusting only was tested.

Material.

A proprietary Derris dust of a somewhat heavy type was used. This was far less bulky than the dust (which contained China clay as a carrier) used in the Sawfly trials (q.v.) and was thus even more dependent on still conditions for satisfactory application.

The rotenone content as determined by Dr. F. Tattersfield of Rothamsted Department of Insecticides was 0·14 to 0·15 per cent. in terms of crude rotenone and 0·13 per cent. as re-crystallized rotenone.

Application.

In the main trial the dust applications were given early in the morning during favourable weather conditions by means of a two wheeled, hand operated, machine.

An early dust (30th March) was applied because weevils were active after a short warm sunny spell, and feeding punctures were plentiful, suggesting that the beginning

of egg laying was imminent. Then came a dull cold period which continued till 3rd April, and egg laying did not begin before 6th April. The second dusting (7th April) was given at the green bud stage and coincided with the beginning of egg laying.

Rather more than a pound of dust per tree was used at the first application and a great deal of the deposit was washed off by a heavy shower which occurred a few hours later.

Rather less than a pound of dust per tree was used at the second application, and no rain fell before 12th April. No appreciable quantity of rain fell till late in April.

An acre of similar trees, planted at 15 ft. square would thus require $1\frac{1}{2}$ to 2 cwt. of dust per acre.

For the subsidiary trial a tractor-drawn hop blower was used, and the dust applied at the rate of about $1\frac{1}{4}$ cwt. per acre. A wind of appreciable force was blowing across the rows and the dust deposit was consequently far from perfect.

Estimation of Results.

To obtain an estimate of the extent of "capping", blossom counts were made on the main trial on 13th May, using as indicators four trees in the centre of each block.

The method adopted was to choose a branch at random on the north side of a tree, and, starting from the tip and working towards the trunk, to count the individual blossoms until a total of 250 was reached, noting at the same time the number of capped blossoms. The count included the blossoms on the lateral shoots of the branch, and if the selected branch bore less than 250 blossoms counting was continued on an adjacent one until the required total was obtained. This procedure was repeated on the east, south and west sides of the tree, thus giving four counts of 250 blossoms—a total of 1,000—from each of four trees per block.

Table I.

Treatment.	% Capped blossoms.	% Reduction.
1. Dusted once—30th March	28·4	—
2. Dusted twice—30th March and 7th April	13·1	58
3. Dusted once—7th April	15·0	52
4. Control—not dusted	31·0	—

Blossom counts made on the subsidiary trial on 15th May gave the following results:

Dusted 31st March	35·0% capped blossoms.
Control, not dusted	39·1% capped blossoms.

Conclusions.

It is evident that the earlier dusting did not result in less "capped blossom", whereas the later dusting gave very promising results.

The matter calls for further study with a view to obtaining more critical information as to the proper timing of the dust.

The complete failure of the earlier dusting might be due to one or more of the following causes:

1. *Bad timing*; too early an application, the dust then becoming washed off or losing toxicity before the period of maximum weevil activity.

2. *Inadequate deposit* owing to—
   (*a*) lack of sufficient foliage to retain the dust.
   (*b*) bad dusting conditions (subsidiary trial only).
3. *Occurrence of rain* soon after dusting (not applicable in the case of the subsidiary trial).

A major difficulty in applying the dust was the scarcity of calm periods. An examination of the Station's wind records suggests that this difficulty is always likely to be experienced at this time of the year. Early morning (between 5.0 and 6.30 a.m.) was found to be the only practicable time for dusting.

The results of these experiments, although promising, require further confirmation before dusting for Apple Blossom Weevil can be recommended to growers.

Summary.

A Derris dust halved the injury caused by Apple Blossom Weevil if applied at the green bud stage, but had no appreciable effect if applied a week earlier.

Possible reasons for the failure of the earlier applications are suggested.

A PROGRESS REPORT ON THE CAUSES OF IMMUNITY TO THE APPLE WOOLLY APHIS *(ERIOSOMA LANIGERUM* HAUSMANN*)*

By R. M. GREENSLADE, A. M. MASSEE and W. A. ROACH

Introduction.

The Apple Woolly Aphis was first recorded in this country in 1782 by Sir Joseph Banks (1). Since then it has gradually spread and at the present time it is a serious pest, especially in nurseries, where the conspicuous appearance of the aphis itself and of the large galls produced by it on young growth renders the trees unsaleable. The pest often causes serious harm in established orchards, especially when the weather is suitable for the rapid reproduction of the aphis. Overseas the woolly aphis is also very important, and in some countries it has been found necessary to exclude all but immune rootstocks in order to arrest the increase of the insect.

Unfortunately the few immune varieties at present available often have serious faults when used as stocks (3). This fact led Mr. M. B. Crane, of the John Innes Institution (2), some ten years ago to attempt to breed stocks which should combine with immunity the other characters necessary in a commercial stock. In 1928 Mr. H. M. Tydeman also commenced similar breeding work at East Malling.

The testing of these stocks takes some ten years, of which five are required for immunity testing (5). Investigations at East Malling have therefore been directed to finding some quicker method of testing for immunity than by direct inoculation with aphides, and so to save these five years.

In 1921 Staniland (6) began a survey of the degree of resistance of the Malling types of Paradise Stocks and other varieties. He found that none of the Malling types were immune to Woolly Aphis, that a high degree of resistance was rare and that there was no connection between immunity and either coarseness of roots or vigour.

Later (7) he investigated the method of feeding, the formation of galls and the mechanical structure of the stem, and concluded that, although degree of resistance above ground seemed to be dependent on the amount and the degree of sub-division of the sclerenchyma, actual immunity could not be explained in mechanical terms.

The feeding of *Aphis rumicus* L. was also investigated and it was found that the stylets could reach as far as those of *E. lanigerum* but no galling was caused, from which it would appear that galling was due to something in the saliva of *E. lanigerum* and not to mechanical stimulation.

In 1924 Le Pelley tested a large number of commercial stocks and scion varieties (4). He found it impossible to classify them according to degree of resistance and proved that the stock had no influence on the scion as regards degree of resistance. Tests of various crosses of Northern Spy made by Mr. M. B. Crane at the John Innes Institution with other varieties indicated that the immunity of the Spy parent is inherited and that Spy is heterozygous in this respect.

PRESENT INVESTIGATION.

Joint work between the Entomology and Biochemistry Sections was commenced in 193[illegible] mainly to determine whether immunity is due to the presence in the immune plants of a chemical substance rendering it toxic or distasteful to the insect or to the presence in the susceptible plants of a substance essential for the healthy growth of the insect. If either of these alternatives were established testing for immunity would resolve itself into a chemical test for this substance.

A number of other lines under investigation, e.g. acidity of sap, etc., will not be mentioned here because so far they have not yielded hopeful results.

In the first year corresponding media made from extracts of susceptible and immune barks were compared as foods for the insect (9). Those prepared from the susceptible bark were consistently better than the corresponding ones prepared from immune bark. Thus the difference between the living trees was, to a limited extent, reflected in the dead aqueous extracts prepared from them.

The media used in 1930 were made by digesting bark at 100° C. for some hours. In 1931 the effect of reducing the preliminary heat treatment was studied. The media were prepared by holding the twig against a machine which tore the bark off in a finely shredded state and shot it into agar or water. Agar preparations were contained in Petri dishes, and the water preparations were made up by the method described in detail later, except that cuticle from current year's apple shoots was used as a membrane. Media II and I were collected from the shredding machine into hot agar and water respectively and heated for a further five minutes in a steam oven. Media III and IV were collected into hot agar and water without further heating and finally cold water was used to collect Medium V, so that this medium was not heated at all.

The collected results for the two years were as follows :

TABLE I.

AVERAGE NYMPHAL LIFE IN DAYS.

	1930.	1931.				
	Agar.	II Agar.	I Cell.	III Agar.	IV Cell.	V Cell.
Water	..	..	5·1	..	4·0	1·7
Agar alone	5·75	5·7	..	4·6	..	..
Susceptible (S)	6·8	1·4	6·55	1·75	9·3	2·7
Immune (I)	4·0	2·8	4·75	1·6	0·5	1·9
Susceptible (S) (neutralized) ..	6·35	..	Susceptible exposed to air.			4·3
Immune (I) (neutralized) ..	3·6	..	Immune exposed to air.			2·5

The varieties used throughout this work were Allington Pippin (susceptible) and Northern Spy (immune).

It will be noticed that two types of media (II and III) gave a shorter nymphal life than agar alone : this suggested the presence in both varieties of a toxic substance having no connection with immunity.

In Table II the media are placed in order of their efficiencies compared with water or agar, i.e. in order of the ratio $\frac{\text{length of life on susceptible medium (S)}}{\text{length of life on water or agar alone (C)}}$ and for each type of medium is given the value of the ratio :

$$\frac{\text{length of life on susceptible medium (S)}}{\text{length of life on immune medium (I)}}$$

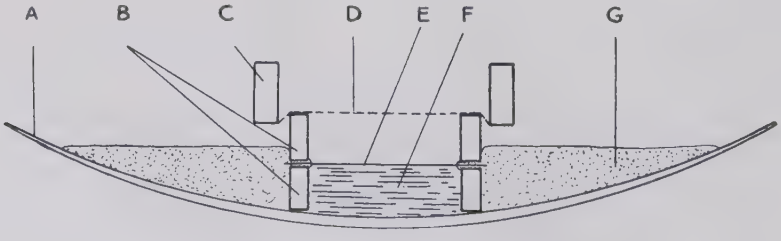
TABLE II.

	1931 IV Cell.	1931 V Cell. Unexposed.	1931 V Cell. Exposed.	1931 I Cell.	1930 Agar. Unneutralized.	1930 Agar. Neutralized.	1931. III Agar.	1931. II Agar.
S/C ..	2·3	1·6		1·3	1·2		0·4	0·2
S/I ..	18·6	1·4	1·7	1·4	1·7	1·7	1·1	0·5

The fact that the lengths of life on the two susceptible media types II and III were actually less than on agar alone proved that some toxic substance was produced in the preparation of the media and it seemed likely that variation in the production of this toxic substance from medium to medium was responsible for the variation in the life periods on them. The presence of any considerable amount of toxic substance in the two media would be bound to mask any other nutritional differences between them. The above figures show that when the feeding effect of the susceptible medium was not swamped by the toxic effect the life period on this medium was consistently longer than on the immune medium ; hence the difference between the living trees as sources of food for the insect was to a limited extent reflected by the dead media. Therefore the substance responsible for this difference must be present in the dead media and it should be possible to isolate it by separating the bark into chemical fractions, by testing each fraction for the presence of the substance and by further splitting up this fraction until a pure substance is obtained which can be characterized by chemical means.

The figures in Table II show that the development of toxicity might be avoided in some measure by carefully controlled heat treatment. Preliminary chemical work (8) on the constituents of bark suggested, however, that the toxic substances might be more easily removed by fractional solution with organic solvents. In 1933, therefore, different portions of shredded bark were extracted with boiling water, alcohol and ether respectively, the extracts and residues being tested separately as food for the insects. The alcohol and ether extracts were first evaporated to dryness on the steam bath and the residues were triturated with boiling water, the water soluble portion alone being tested. These water soluble portions will for brevity be referred to as " alcohol extract " and " ether extract " respectively.

The food was placed in a cell similar to those used before (see diagram).



Apparatus for feeding woolly aphides.

A Watch glass.
B Glass rings.
C Iron ring.
D Silk.
E Membrane.
F Food medium.
G Paraffin wax.

Two glass rings (B) were stuck on either side of the membrane (E) with paraffin wax, thus forming two cells. One cell was filled with the food and a watch glass (A)

placed over it. The whole was then inverted and the cells sealed into the watch glass by pouring in paraffin wax (G).

Preliminary experiments showed that fish skin (Dutch skin) could with advantage be substituted for the apple cuticle hitherto employed, so this membrane was used throughout the 1933 trials. The aphides were placed in the top cell. They were prevented from wandering by a silk lid held down by an iron ring slightly larger than the glass cell.

To obtain nymphs of known age adult viviparous females were placed in the feeding cells overnight and removed next morning; hence the nymphs produced did not vary in age by more than sixteen hours. They were counted and examined every day, the dead ones being removed. It was found necessary to transfer them to fresh cells every other day.

The results obtained are tabulated below.

TABLE III.

Treatment.	Trials showing Allington better than Spy.	Trials showing no difference.	Trials showing Spy better than Allington.	Total number of Trials.
Water extracted bark ..	4	..	3	7
Water extract ..	3	1	2	6
Alcohol extracted bark ..	6	..	1	7
Alcohol extract	1	..	2	3
Ether extracted bark ..	..	..	4	4
Ether extract ..	1	..	..	1

It will be seen that the most hopeful results were obtained by alcohol and ether extraction. In six of the seven comparisons made with alcohol extracted bark residues the susceptible residue gave the longer life period, whereas the susceptible alcohol extract did not give a better life period than the immune. Apparently therefore the immunity- or susceptibility-conferring substance was not extracted by alcohol. In all four comparisons made with the ether extracted bark residues the immune was actually better than the susceptible. The single comparison made with the ether extract showed the susceptible better than the immune. These two facts suggest that the substance was extracted by the ether.

Should further work confirm the above conclusions that the substance is insoluble in alcohol but soluble in ether a big step will have been made towards its isolation in a state of purity.

Chemical work along the lines suggested by these facts has already been commenced.

FUNCTION OF ASSOCIATED YEAST.

Reference has already been made to a yeast so far found constantly associated with Woolly Aphides (9). This yeast Dr. H. B. Hutchinson, of the Distillers Company Limited, has very kindly determined as *Torula Rubra*.

In order to throw light on the function of this yeast two parallel series of media were made up differing only in that one series contained the yeast and the other did not. The life periods obtained were as follows :

	With yeast.	*Without yeast.*
Water extracted susceptible bark	29·4 days	20·7 days
Alcohol extracted susceptible bark	16·9 ,,	15·3 ,,
Water extracted immune bark	18·1 ,,	17·2 ,,
Alcohol extracted immune bark	16·8 ,,	14·6 ,,

No moulting was noted ; the trial, however, was carried out in December and January, when development would naturally be slow. But it will be noticed that each medium containing yeast gave a longer life period than the one without yeast. This hopeful indication will be followed up early next season.

Summary.

1. Investigations of the causes of immunity are outlined.
2. Methods for feeding the aphides on artificial media are described.
3. The function of a yeast associated with the insect is being investigated.
4. The results suggest that the cause of immunity or susceptibility is carried by a substance which is insoluble in alcohol and soluble in ether.

References.

(1) Banks, J. " Notes relative to the first appearance of the *Aphis lanigera* or the Apple tree insect in this country." Trans. Hort. Soc., 1815, **2** (1st Series), 162-9.

(2) Hall, Sir Daniel and Crane, M. B. (1933). " The Apple," 169-70.

(3) Hatton, R. G. " The Northern Spy Apple as a Rootstock." E. Malling Res. Sta. Ann. Rep. for 1926-7 (II Supplement), 1928, 44-50.

(4) Le Pelley, R. " Studies on the Resistance of Apple to the Woolly Aphis (*Eriosoma lanigerum* Hausm.)." Journ. Pom. and Hort. Sci., 1927, **6**, 209-41.

(5) Massee, A. M. " The Resistance of certain Apple Stocks to attacks of the Woolly Aphis." E. Malling Res. Sta. Ann. Rep. for 1928-30 (II Supplement), 1931, 202-5.

(6) Staniland, L. N. " The immunity of apple stocks from attacks of Woolly Aphis," Part I. Journ. Pom. and Hort. Sci., 1923, **3**, 85-95.

(7) Staniland, L. N. " The immunity of apple stocks from attacks of Woolly Aphis." Part II. Bull. Ent. Res., 1924, **15**, 157-70.

(8) Roach, W. A. " Chemical examination of Apple bark." E. Malling Res. Sta. Ann. Rep. for 1931, 35.

(9) Roach, W. A. and Massee, A. M. " Preliminary experiments on the physiology of the resistance of certain rootstocks to attack by Woolly Aphis." E. Malling Res. Sta. Ann. Rep. for 1928-30 (II Supplement), 1931, 111-20.

SOME NOTES ON THE WOOLLY APHIS PARASITE (*APHELINUS MALI* HALD.)

By R. M. GREENSLADE AND A. M. MASSEE

THE first attempt to establish the Woolly Aphis parasite in Kent on a field scale was made by Theobald (1) in 1925 at Hoo, near Rochester. The parasites did not become established because the Woolly Aphis in the orchard died out completely during the Summer.

Since that time several attempts have been made to establish the parasite in different parts of Kent. In most instances the parasite failed to establish itself. However, there was one exception at Chislehurst in 1929 (2). The parasites became established in the Summer of that year, lived throughout the Winter, and spread sufficiently in 1930 to wipe out the Woolly Aphis in the orchard. An account of other attempts made to establish the Woolly Aphis parasite in various parts of England has been published by Fryer (3) in the Bulletin entitled " Insect Pests of Crops 1928-31 ".

Further efforts to establish the Woolly Aphis in two centres in Kent were made in 1933. Two orchards were selected which had been infested with Woolly Aphis for many years, one being situated at East Malling and the other at Paddock Wood.

In the orchard at East Malling a serious infestation of Woolly Aphis was beginning to develop on seven rows of Allington Pippins (a very susceptible variety) planted on the square, 16 ft. apart, and interplanted with the variety Lord Derby. During the early part of the year only the first four rows of Allingtons were infested, the remaining rows and all the Derby's being free of the pest.

On the 1st March, 1933, *Aphelinus mali* Hald. was introduced into the orchard by placing gauze fly traps containing parasitized aphids in the seventh and eighteenth trees of the first row of Allingtons.

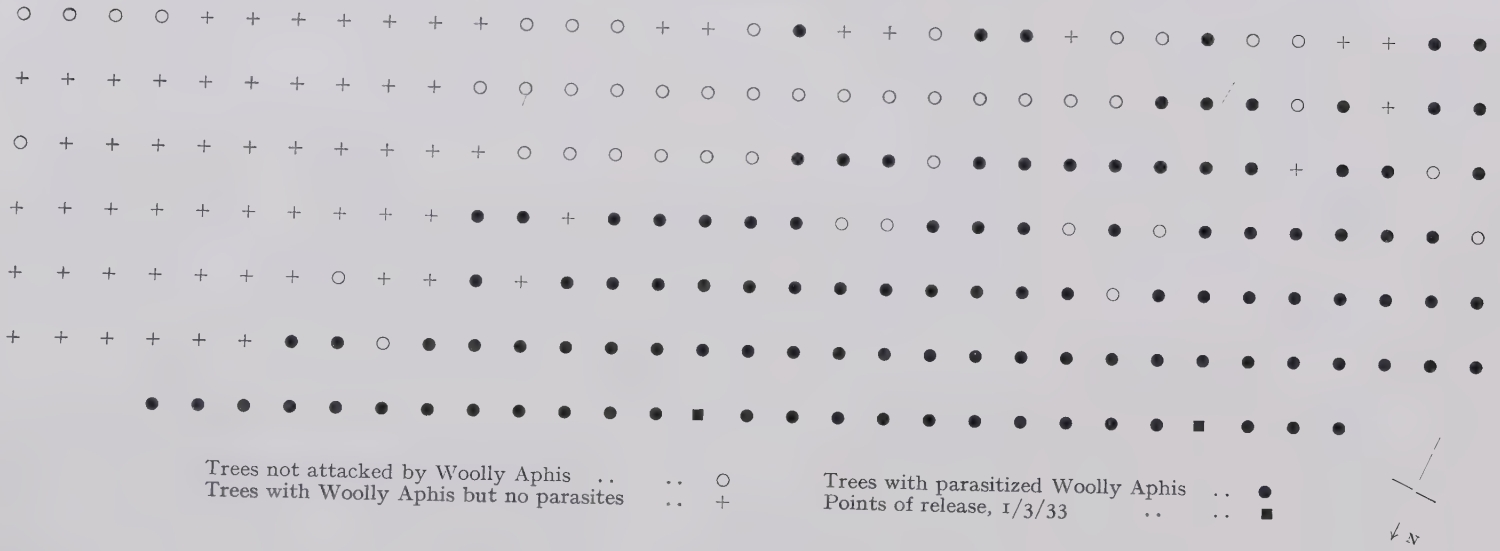
One or two parasites were noted flying about during the second week of May, but in general the hatching did not commence until some time later.

During the early Summer the infestation of Woolly Aphis was particularly severe on the first three rows, and the S.W. ends only of the remaining rows. By the latter part of September it spread to the other end of these rows, and in October the Woolly Aphis appeared in small colonies on the interplanted rows of Lord Derby.

The parasite spread during the season throughout the infested area of the orchard, and on examination on the 28th September showed parasitized aphids on eighty-seven trees out of 138 infested with Woolly Aphis. Eight trees round one point of release and three round the other showed 100 per cent. parasitization at that date. A further examination on 17th November showed parasitized aphids on 129 trees out of 241 attacked by Woolly Aphis. This figure includes the Lord Derby's which are omitted from the diagram (p. 226) and none of which were attacked at the time of the September examination.

In the course of its spread the parasite travelled against the prevailing wind (which was S.W. during most of the Summer) and penetrated the intervening rows of unattacked trees between the rows of Allingtons. A few parasitized Woolly Aphids were

Spread of *Aphelinus mali* at Kiln Barn, East Malling, between 1st March and 17th November, 1933.


Trees not attacked by Woolly Aphis
Trees with Woolly Aphis but no parasites
Trees with parasitized Woolly Aphis
Points of release, 1/3/33
N

found on an older tree 144 yds. from the point of release, beyond twenty rows of Grenadiers not attacked by Woolly Aphis.

Full details of the spread of the parasite are given on the accompanying diagram.

The orchard received the following sprays during the season, but none of them seemed to have any adverse effect upon the parasite: 28/12/32 6 per cent. Tar Distillate; 19/3/33 5 per cent. lime-sulphur; 16/5/33 1 per cent. lime-sulphur; and 27/5/33 1 per cent. lime-sulphur.

It will be noted that the last three sprays were applied after the release of the parasite, but as already stated none of them seemed to have any effect upon it.

A complete clearance of aphids occurred on the trees immediately surrounding the points of release before the time when previously uninfected trees were attacked, so that it seems probable that a more complete control might be achieved with a sufficient number of points of release.

The establishment of the Woolly Aphis parasite in the orchard at Paddock Wood was by no means successful. Some Blenheim trees in the orchard were very severely infected with Aphis, and the parasite would appear to have had every reasonable chance of establishing itself, especially in a favourable season such as that of 1933.

Cages were put in the orchard at six points, and these trees were left unsprayed. By the 2nd September the parasite had spread only a little way, and it was decided to reintroduce it at thirteen new points in the orchard. On 3rd October, twenty-five trees were noted with parasitized aphids on them.

Probably there was not a complete generation of Aphelinus between 2nd September and 3rd October, which would account for the lack of the spread compared with the orchard at East Malling during the latter part of the Summer.

The Woolly Aphis attack became so serious at Paddock Wood that the grower was compelled to spray against it on four occasions between the beginning of April and the end of August. These spraying operations would doubtless tend to check the parasite since nicotine was used in two of the applications.

This investigation was carried out in collaboration with Mr. A. S. Buckhurst of the Plant Pathological Laboratory, Milton Road, Harpenden, Herts, all the woolly aphis parasite material being obtained from that source.

Summary.

A brief account is given of two attempts to establish the woolly aphis parasite in Kent in 1933.

It is shown that while the parasite became fairly well established at one centre, it failed to establish itself at another place where the conditions seemed to be ideal for the breeding of this insect.

References.

(1) Theobald, F. V. "Report of the Research and Advisory Dept." S.E.A. College, Annual Report, 1925-26, 11.

(2) Massee, A. M. "Notes on Mites and Insect Pests for the Years 1928-30." E. Malling Res. Sta. Ann. Rep. for 1928-30 (II Supplement) (April, 1931), 200.

(3) Fryer, J. C. F. "Insect Pests of Crops, 1928-31 (1933)." Bull. No. 66, Min. of Agric. and Fisheries, 10.

TORTRIX INVESTIGATIONS IN 1933

By G. L. HEY AND A. M. MASSEE

As mentioned in the East Malling Report for 1932 the apple surface eating Tortricids were considered to be very important pests in many parts of the country, but at that time very little information was available concerning the species responsible for the damage to the apples, and the life-cycles of the insects were but little understood.

In 1933 the investigations upon these insects were continued, and a study was made into the life histories and economic importance of several Tortricidae on apple, pear, plum, cherry, raspberry, walnut, hawthorn and privet, with special reference to the species damaging the fruit of the apple.

Through the kindness of several fruit growers and numerous colleagues, specimens have been obtained from several widely different fruit growing areas.

At the present time about 400 moths and parasites have been bred out in an incubator which proved invaluable for the purpose. The moths were sent to Mr. T. Bainbrigge Fletcher for identification and the writers are very greatly indebted to him for the determination of the species, without which no progress could have been made. The most important species proved to be *Cacoecia podana* Scop. and a full account of its biology and morphology will be published elsewhere. This investigation has shown that the damage mainly attributed to *Batodes angustiorana* Haw., is nearly always due, however, to *C. podana* Scop.

From a total of 3,350 larvae collected in September, 1933, crawling over Bramley's Seedling apples in the packing shed of a cold store, 85 per cent. were *C. podana* Scop., 10 per cent. *B. angustiorana* Haw., and 5 per cent. were *Spilonota ocellana* Fabr.

These three species were also noted in the Autumn as injurious to the fruits of pear, plum and damson, causing the same type of damage as on apple.

C. podana was bred from apple, pear, plum, cherry, damson, quince, walnut, raspberry, blackberry and hawthorn. *B. angustiorana*, however, was bred only from apple, pear, plum and damson. The observed host plants of *Spilonota ocellana* Fabr. were apple, pear, plum, cherry, damson, quince, raspberry, blackberry and hawthorn.

Observations have been made in several localities on the percentage of apple fruits of different varieties damaged by the larvae of these three species. The percentage of damaged fruits varied from 2 per cent. to 34 per cent. The results are summarized below in Table I.

The other species bred out were only rarely concerned with damage to the fruit in Autumn. *Cacoecia lecheana* L. was bred from apple, pear, cherry and walnut; *Tortrix diversana* Hb. from apple, pear and privet; *Argyroploce variegana* Hb. from apple, pear, cherry and hawthorn; *Pandemis heparana* Schiff. from apple and pear; and *Pandemis ribeana* Hb. and *Peronea contaminana* Hb. from apple, pear, plum and hawthorn.

In addition a few specimens of *Cacoecia sorbiana* Hb. were bred from apple and of *Acroclita naevana* Hb. from pear. A single specimen of *Pammene rhediella* Cl. was bred from apple, one of *Peronea comparana* Hb. from raspberry and one of *Cacoecia rosana* L. from black currant.

In one orchard large numbers of larvae and pupae of a species as yet undetermined were discovered sheltering in corrugated weevil bands in October. In addition several

TABLE I.

No.	% of Fruit damaged by Tortrix larvae.	Variation in % damage per tree.	No. of apples examined.	Variety of Apple.	No. of trees.	Locality.	Date of Examination.	Other Details.
1	2%	1-4%	1,366	Newton Wonder	4	E.M.R.S. Plot IV	26th September	Sample taken in field.
2	4%	2-5%	930	Cox's Orange Pippin	4	Plot III	23rd September	Sample taken in field.
3	4%	1-13%	16,091	Lane's Prince Albert	56	Plot X	15th September	Total crop examined in field.
4	5%	3-6%	962	Court Pendu Plat	4	Plot 33	22nd September	Total crop examined in field.
5	6%	1-16%	5,027	Annie Elizabeth	30	Plot III	26th September	Total crop examined in field.
6	6%	3-14%	738	Allington Pippin	4	Plot IV	26th September	Sample taken in field.
7	7%	5-9%	623	Norfolk Beauty	4	Plot III	22nd August	Sample taken in field.
8	7%	0-21%	3,532	James Grieve (Paradise)	32	Plot III	2nd September	Total pick examined in field.
9	9%	2-21%	4,559	James Grieve (Free)	31	Plot III	1st September	Total pick examined in field.
10	20%	3-33% (per box)	540	Lord Derby	4 boxes	Plot III	23rd September	Sample taken in field.
11	13%	10-16% (per box)	773	Royal Jubilee	5 boxes	Crockenhill, nr. Swanley Junc.	20th September	Sample taken in store.
12	15%	7-28% (per box)	530	Duchess Favourite	4 boxes	Crockenhill, nr. Swanley Junc.	20th September	Sample taken in store.
13	19%	16-21% (per box)	290	Lane's Prince Albert	2 boxes	East Malling	27th September	Sample taken in store.
14	31%	25-49% (per box)	935	Bramley's Seedling	8 boxes	West Farleigh	18th September	Sample taken in store.
15	34%	26-53% (per box)	1,041	Bramley's Seedling	8 boxes	East Malling	27th September	Sample taken in store.
16	3%	0-15%	10,386	Worcester Pearmain	53	East Malling	21st August	Total crop examined in field.

adults of the Tineid *Anthophila* (=*simaëthis*) *pariana* Clercll. were bred out from apple and this species was found to be widely distributed.

Investigations have also been undertaken in collaboration with Dr. West of Ditton Laboratory, East Malling, concerning the effects of various gas mixtures on the larvae in cold store. The results of these experiments are published elsewhere in this report.

Summary.

An account is given of the species of Tortricids which were bred at East Malling during 1933.

The commonest species proves to be *Cacoecia podana* Scop. which feeds upon the surface of the apples in the packing sheds and cold stores.

Thirteen other species of Tortricids and one Tineid were also bred out, and a list of species together with their host plants is referred to briefly.

OBSERVATIONS ON THE EFFECTS OF VARIOUS GAS MIXTURES OF KNOWN COMPOSITION ON TORTRIX LARVAE IN STORE

By G. L. HEY AND A. M. MASSEE

THESE observations were carried out at the Ditton Laboratory, East Malling, the equipment of which proved to be ideal for this type of work. A certain number of the gas mixtures which were being used for the preservation of apples in store, after being passed through the gas-tight cabinets containing the apples, were led into tins about 10 ins. square and 10 ins. deep, and then allowed to escape by an outlet pipe into the atmosphere. Inside these tins were smaller tins containing definite numbers of Tortrix larvae and a few Bramley's Seedling apples. From these small tins a circular piece was removed from the top and bottom and pieces of gauze soldered on to allow free diffusion of the gases into the tins and all joints and the lid were sealed over with paraffin wax to make sure that no larvae escaped. The outer tin which acted as a reservoir for the gas mixture had its lid rendered airtight by a thick coating of vaseline. Thus the same gases which were being tested inside the cabinet for fruit preservation were utilized for the determination of their effect upon Tortrix larvae under the same conditions. The storage cabinets were all in the same chamber of the cold store which was kept at a constant temperature of 3° C. (37·5° F.).*

The larvae were practically all in the third instar and, as far as could be ascertained, all of the one species *Cacoecia podana* Scop. The tins containing the larvae were removed at intervals and the number of dead and living larvae counted. As these tins were removed, others were made up and put in their place. By this means it was possible to arrange several series of tins exposed to the gases for different periods of time from September to December, 1933.

There were seven different treatments as outlined below :

I. 10% oxygen, 15% carbon dioxide, 75% nitrogen.
II. 10% oxygen, 10% carbon dioxide, 80% nitrogen.
III. 10% oxygen, 5% carbon dioxide, 85% nitrogen.
IV. 5% oxygen, 10% carbon dioxide, 85% nitrogen.
V. 2·5% oxygen, 10% carbon dioxide, 87·5% nitrogen.
VI. Air, which for the purposes of this experiment may be taken as comprising 21% oxygen, 79% nitrogen.
VII. Air, but the tin was not connected at all to a cabinet, so that the larvae were exposed only to air and not, as in VI, to air plus the volatile substances produced by the apples in the cabinet.

Treatment VI, therefore, can be regarded as a true control, but treatment VII cannot be regarded as such.

* For particulars *re* the production of these gases and their use for the storage of fruit, see Kidd, F., and West, C. (1933), "Gas Storage of Fruit : III. Lane's Prince Albert Apples." *Journ. Pom. and Hort. Sci.*, XI, No. 2, June, pp. 149-70.

Table I.

The Effect of Various Gas Mixtures on Tortrix Larvae Exposed to them for Different Numbers of Days at a Constant Temperature of 3° C. (37·5° F).

	Treatment, Composition of Gas Mixture.	Number of Days' Exposure and Number of Larvae per Tin.													
		days 71		days 51		days 38		days 31		days 14		days 11		days 7		days 7	
		larvae 100		larvae 50		larvae 25		larvae 25		larvae 25		larvae 25		larvae 25		larvae 10	
		Amt. of feeding.	% larvae killed.	Amt. of feeding.	% larvae killed.	Amt. of feeding.	% larvae killed.	Amt. of feeding.	% larvae killed.	Amt. of feeding.	% larvae killed.	Amt. of feeding.	% larvae killed.	Amt. of feeding.	% larvae killed.	Amt. of feeding.	% larvae killed.
I	10% O_2, 15% CO_2, 75% N_2 ..	Slight	84	None	96	Slight	96	Slight	84	None	71	None	60			None	73
II	10% O_2, 10% CO_2, 80% N_2 ..	Slight	100	None	100	Slight	100	None	100	None	57	None	54	None	33	None	88
III	10% O_2, 5% CO_2, 85% N_2 ..	Slight	100	None	96	Slight	62	Slight	72	None	57	None	61			None	78
IV	5% O_2, 10% CO_2, 85% N_2 ..	Slight	100	None	100	Slight	100	None	88	None	68	Slight	60			None	50
V	2·5% O_2, 10% CO_2, 87·5% N_2	None	99	None	100	None	100	None	100	None	84	None	84	None	53	None	56
VI	Control (air) 21% O_2, 79% N_2	Little	48	Slight	50	Little	32	Little	25	Slight	28	Slight	15	Little	7	Slight	10
VII	21% O_2, 79% N_2	Little	69	Slight	52	Mod.	16	Mod.	24	Slight	28	Slight	12	Little	10	Slight	0

The table opposite shows the results obtained (the amount of feeding is expressed in ascending order as None, Slight, Little, Moderate).

It will be seen from the above table that gas mixture V was the most successful in preventing damage to the fruit by the larvae, and in its lethal action on the larvae. This was probably due to the low percentage of oxygen it contained ; the lack of oxygen even if it did not kill all the larvae probably rendered them sluggish, so that they did not feed at all. Kidd and West* have shown that for the gas storage of Lane's Prince Albert apples an atmosphere containing 2·5 per cent. oxygen and 5 per cent. carbon dioxide at 4° C. will double the storage life of the fruit. From the above experiment, it can be recommended that such a mixture will greatly reduce if not entirely prevent feeding by Tortrix larvae on the apples in store. For the variety Bramley's Seedling the same writers have shown* that the optimum conditions for storage are a temperature of 5° C. and an atmosphere containing 10 per cent. (approximate) oxygen and 10 per cent. (approximate) carbon dioxide. It will be noted that this gas mixture will greatly reduce feeding by Tortrix larvae on the apples in store, but not to quite the same extent as the gas mixture recommended for the Lane's.

From a practical standpoint, therefore, after picking, the sooner the apples are placed in cold storage in a suitable gas mixture, the less they will be damaged by the feeding of Tortrix larvae. By the time the apples come to be removed from storage, which will normally be after Christmas, all the Tortrix larvae will be dead.

The writers are greatly indebted to Dr. West for the facilities put at their disposal for the purposes of this investigation, which could not have been undertaken without his interest and practical help.

Summary.

The effects of certain gas mixtures upon the larvae of the Apple Fruit Tortrix *Cacoecia podana* Scop., a species of insect which feeds upon apples under storage conditions, are described.

From a practical standpoint it is shown that the fruit should be placed under suitable storage conditions as soon as possible after packing in order to lessen the feeding of the larvae.

The control of the larvae is also very important from another point of view. When the larvae have been feeding for some time on the fruits soft Brown Rots set in, which may cause the complete breakdown of the fruits. This type of injury is frequently more severe than that caused by the actual feeding of the larvae.

* Kidd, F., and West, C., " Gas Storage of Fruit: II." *Journ. Pom. and Hort. Sci.*, VIII, No. 1, 1930, p.67.

MISCELLANEOUS OBSERVATIONS ON APPLE SAWFLY *(HOPLOCAMPA TESTUDINEA* KLUG.*)* IN 1933

By G. L. HEY AND W. STEER

THE following observations were for the most part made whilst carrying out the field work on the control of Apple Sawfly which is described elsewhere (4). They may conveniently be dealt with under the following headings :

1. The Larval Instars.
2. Migration of the Larvae.
3. Depth of Pupation.
4. Varietal Susceptibility.

1. The Larval Instars.

Miles (7) states that the larva of *H. testudinea* has five instars, and that the fifth and ultimate instar is easily distinguished from the preceding instars by having a pale, instead of a black, head and pale, instead of dark brown, dorsal plates on certain abdominal segments. He also gives head width measurements of the five instars and calculates from them a simple growth ratio which conforms to " Dyar's Rule " (3).

Larvae, collected in the course of experiments described below, were preserved in Pampel's fluid and subsequently examined* in order to refer them to their appropriate instars by means of Miles' data. Although it was found possible to separate five instars without much difficulty, the head width measurements were consistently smaller than those published by Miles. The measurements, all of *unmounted* specimens, are summarized in Table I, where Miles' figures are also given (in brackets) for comparison.

TABLE I.

HEAD CAPSULE WIDTHS OF LARVAE OF *H. testudinea*.

Instar.	Number examined.	Head width in mm.		Growth ratio.
		Range.	Average.	
I.	2	0·32–0·36	0·34 (0·392)	— —
II.	22	0·46–0·56	0·52 (0·550)	1·53 (1·4)
III.	15	0·68–0·76	0·72 (0·786)	1·38 (1·4)
IV.	11	1·00–1·08	1·03 (1·106)	1·43 (1·4)
V.	85	1·20–1·40	1·32 } (1·526)	1·28 } (1·38)
VI.	88	1·40–1·52	1·48 }	1·12 }

* We wish to acknowledge the help given to us by Mr. F. J. D. Thomas who carried out the rather laborious task of measuring these larvae and who helped to recover and record the cocoons in the experiments on depth of pupation.

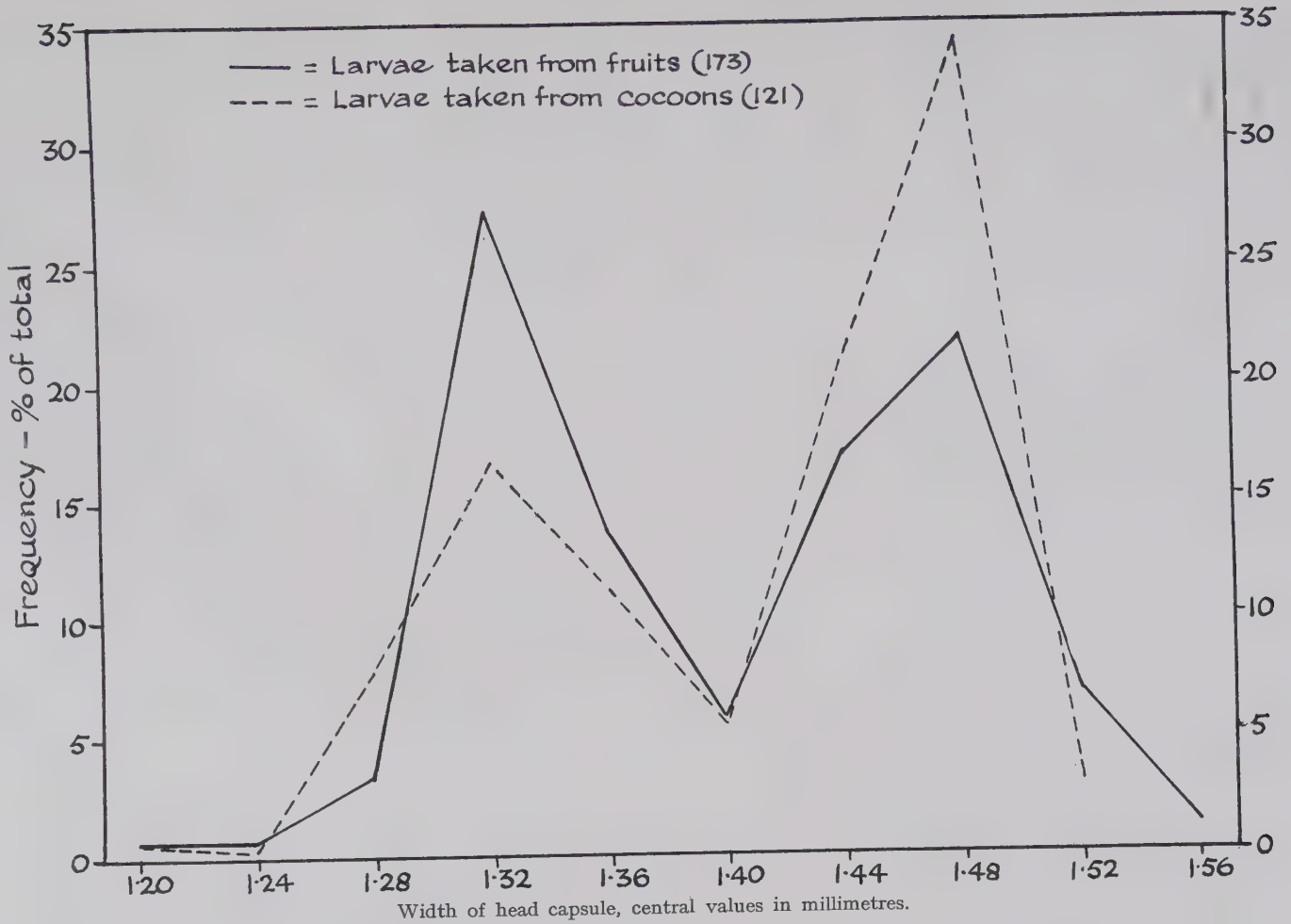


FIG. 1.

Head width measurements of the reputed "fifth" instar of *Hoplocampa testudinea* Klug.

When the head width measurements of the reputed fifth and ultimate instar were tabulated it was at once apparent that their frequency curve was bimodal, with modes at the values 1·32 mm. and 1·48 mm. (Fig. 1). This first suggested the possible existence of a sixth instar, with a growth ratio to the fifth instar of 1·12.

To obtain further information a large number of cocoons were opened and the hibernating larvae extracted from them. These resembled the larvae obtained earlier, and could also be classified as having larger or smaller head capsules (Fig. 1). Thus it seemed that a sixth instar does occur but that the hibernating larva may be either a fifth or a sixth instar. The likeliest explanation seemed that the extra instar is confined to one sex. It will be observed (Fig. 1) that of the larvae obtained in the Summer the smaller size predominates, but that this relationship is reversed in the case of the larvae extracted from cocoons. This suggests that the smaller size represents the ultimate instar of one sex and the penultimate instar of the other.

It might reasonably be expected that such a difference in head capsule size would, if connected with sex, persist in the adult. Measurements of a few adults are summarized in Table II.

TABLE II.

HEAD WIDTHS OF ADULTS OF *H. testudinea*.

Sex.	Number examined.	Average head width.	Ratio.
Male	14	1·65 mm.	—
Female	18	1·85 mm.	1·12

It is noteworthy that the ratio between the head widths of female and male (1·12) is similar to the ratio between the two sizes of larval head capsule (Fig. 1).

The evidence all points to the occurrence of a sixth larval instar in the female sex only. In this connection it is pertinent to point out that Miles (8) records the occurrence of an extra instar, confined to larvae which become females, in certain other species of sawfly, viz. *Pteronus ribesii* Scop., *P. leucotrichus* Htg., and *Ametastegia glabrata* Fall.

This investigation is being continued with a view to securing additional data on the correlation with sex of (*a*) the number of larval instars, (*b*) larval head capsule size and (*c*) cocoon size.

2. Migration of the Larvae.

Secondary infestation, the attack of sound fruitlets by larvae which have left infested ones, is one of the most important phases of sawfly attack. Massee (5) and Bush (1) have noted the nocturnal and early morning migrations of such larvae. They enter sound fruits by eating a hole in the side and so greatly increase the loss due to sawfly.

Effect of Spray Treatment.—It was to arrest this secondary infestation by control of the migrating larvae that a field trial (4) of Derris dust, nicotine and soap and Derris and soap was carried out on some trees of Early Victoria. The spray and dust applications were made on 30th May, eighteen days after petal fall.

To measure the progress of migration several branches were selected on representative treated and control trees and the numbers of clean and infested apples on them were recorded. A tag was at the same time tied to each infested fruit. The branches were examined on fifteen subsequent occasions up to 28th June, and each new case of

secondary attack was duly recorded and tagged. It was clear at the outset that the experiment was started too late to record the earliest migrations, for by 30th May many apples had already been entered by migrating larvae.

Records of a second similar series of branches were begun on other (untreated) trees on 11th June. No new cases of secondary attack occurred after 18th June. The records are given in Table III.

TABLE III.

SECONDARY ATTACK OF EARLY VICTORIA FRUITLETS BY LARVAE OF THE APPLE SAWFLY.

Initial number attacked on 30th May.	Number of Fruits subsequently attacked; recorded on June:—												Increase	
	2nd.	4th.	6th.	8th.	9th.	10th.	11th.	13th.	14th.	15th.	17th.	18th.	Total	%
On Trees dusted with Derris (4 branches).														
2	–	–	–	–	–	–	–	–	–	–	–	–	0	0
25	1	–	3	–	–	–	–	–	–	–	–	–	4	16
53	–	1	2	–	–	–	–	–	–	–	–	–	3	5
2	–	–	–	–	–	–	–	–	–	–	–	–	0	0
On Trees sprayed with Nicotine (3 branches).														
12	–	–	–	–	–	–	–	–	–	1	–	–	1	8
11	1	2	–	–	–	–	–	1	1	–	–	–	5	45
24	1	2	–	1	–	–	–	–	–	–	1	1	6	25
On Trees sprayed with Derris (3 branches).														
16	–	4	2	1	–	–	–	–	–	–	–	–	7	44
31	–	–	3	2	3	1	–	1	–	–	–	1	11	35
2	–	–	–	1	–	–	–	–	–	–	–	–	1	50
On unsprayed Trees (2 branches).														
8	–	–	2	–	–	1	–	–	–	–	–	–	3	37
13	–	4	2	1	3	3	2	–	–	–	–	–	14	108
On unsprayed Trees (2nd series—6 branches, started 11th June).														
3								–	–	–	–	–	0	0
5								2	–	1	–	–	3	60
5								1	–	–	–	–	1	20
5								1	–	–	1	–	2	40
7								–	–	–	–	–	0	0
5								1	–	–	–	–	1	20

It will be seen that although a great many fruits were attacked on the untreated branches after 30th May, very few were attacked on the branches dusted with Derris. Nicotine-soap and Derris-soap were less effective than the dust, but each somewhat reduced the secondary attack. The effect of the various treatments on the rate of increase in the numbers of secondarily attacked fruits is shown in Fig. 2.

Massee (5) has also recorded the effect of dusting for migrating larvae. His Derris dust* was applied on 22nd June, 1932 (when probably most of the larvae were mature or nearing maturity) and he states that during the course of four days many more larvae fell from dusted than from undusted trees.

Instars Concerned in Migration.—From time to time secondarily attacked fruits were collected from unsprayed trees and from the ground beneath them. From these the larvae were removed, preserved, and subsequently referred to their instars. Table IV

* This dust, which was specially prepared for the purpose by one of the present writers, contained 0·19 per cent. (approx.) of rotenone.

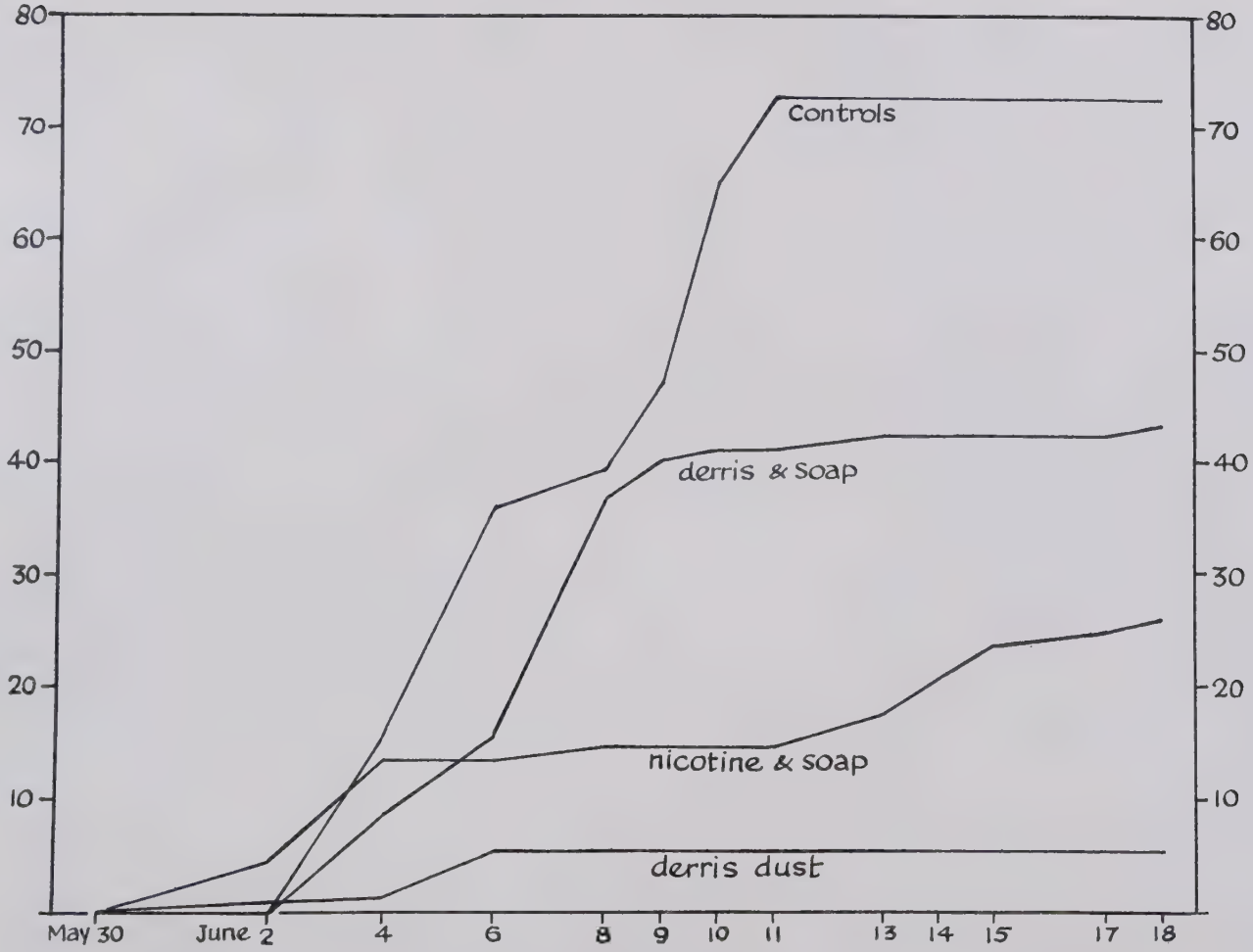


FIG. 2.

Rate of increase in the numbers of secondarily attacked fruits and the effect of spray treatment on it.

shows the occurrence of the various instars over the period during which records were taken.

TABLE IV.

Date.	Instars found in fruits picked off the tree.							Instars found in fruits picked up from the ground.						
	I.	II.	III.	IV.	V.	?	VI.	I.	II.	III.	IV.	V.	?	VI.
30th May	–	10	7	–	–	–	–	–	–	–	–	–	–	–
1st June	2	10	1	–	–	–	–	–	–	–	–	–	–	–
2nd ,,	–	2	7	–	–	–	–	–	–	1	–	–	–	–
6th ,,	–	–	–	–	–	–	–	–	–	–	3	–	–	–
7th ,,	–	–	–	2	–	–	–	–	–		–	–	–	–
8th ,,	–	–	–	2	–	1	1	–	–	–	–	–	–	–
9th ,,	–	–	–	1	5	–	2	–	–	–	–	–	–	–
10th ,,	–	–	–	1	6	–	1	–	–	–	–	–	–	–
11th ,,	–	–	–	3	10	1	7	–	–	–	–	6	–	1
13th ,,	–	–	–	–	6	2	7	–	–	–	–	7	2	6
15th ,,	–	–	–	–	5	1	7	–	–	–	–	5	–	12
17th ,,	–	–	–	–	9	–	10	–	–	–	–	8	1	6
21st ,,	–	–			6	1	13	–	–	–	–	1	–	4

The column headed " ? " refers to the few larvae whose head capsules were intermediate in width between instars V and VI.

Miles (7) states that migration does not begin before the third instar is reached. Our observations showed, however, that the second (and possibly the first) instar is also concerned in migration. On 30th May, when these observations were initiated, migration had already begun and secondarily attacked fruitlets were abundant. Some of these contained second, others contained third instar larvae. Then, on 1st June, two first and four second instar larvae were found dead on the outsides of some of the dusted fruitlets, into which they had apparently previously migrated.

That the later instars are also concerned in secondary infestation is evident from a comparison of Tables III and IV.

3. The Depth at which the Larvae construct their Cocoons.

It has been recorded by Theobald (9) that the larvae normally construct their cocoons at a depth of 1 to 4 ins. in the soil; Massee (6) on the other hand, has stated that larvae occur " at considerable depths ". Miles (7) made a test and found that, of the twenty-five cocoons he recovered, the majority were constructed at a depth of 3 to 9 ins., a few occurring above or below this depth. Since the cylinder he used was only 10 ins. deep, he was unable to show whether or not cocoons are constructed at much greater depths.

In order to obtain further data, two drain pipes, each 25 ins. long by 4 ins. internal diameter, were sunk separately up to the rim in the ground. They were filled with soil which was then pressed down a little to consolidate it but not rammed hard. The soil was allowed to settle for two days and more soil was added as required. Then, on 18th June, 100 mature larvae were placed on the soil in each pipe. They were observed to burrow down rapidly and within fifteen minutes had all disappeared. Most of them entered the soil in less than five minutes. To keep out predators, a piece of muslin was fastened over the top of each pipe.

On 2nd October, the pipes were removed and the soil examined inch by inch. The cocoons were easily recovered by washing the soil through a sieve and then picking them out of the remaining debris or floating them out in water.

In another experiment three large flower pots 10 ins. in depth and 11 ins. rim diameter were filled with soil and sunk to the rim in the ground. After a few days' interval to allow the soil to settle fifty larvae were on 24th June placed in each of the pots, which were then covered with muslin. On 29th September they were taken up and examined.

Table V shows the number of cocoons recovered and the depths at which they were found. Of the 321 cocoons recovered 286 (i.e. 89 per cent.) were found in the top 4 ins. of soil.

TABLE V.

NUMBER OF COCOONS RECOVERED.

Depth in inches.	Pipe 1.	Pipe 2.	Pot 1.	Pot 2.	Pot 3.
0–1	56	9	4	6	2
1–2	37	34	8	18	17
2–3	5	33	6	12	8
3–4	2	10	6	6	7
4–5	0	3	4	2	5
5–6	0	0	3	2	3
6–7	0	0	4	2	2
7–8	0	0	1	0	1
8–9	0	0	0	0	3
below 9	0	0	0	0	0
Total recovered	100	89	36	48	48
Per cent. recovered	100	89	72	96	96

4. Varietal Susceptibility to attack by Sawfly.*

Miles (7) has published data for 1931 on larval damage to a number of apple varieties in Cheshire. Bush (2) has published a similar list of varieties showing the degree of attack (estimated from blossom counts) at a Worcestershire centre in 1933.

Table VI shows the dates of full bloom and the degree of attack on some of the varieties examined by us at East Malling in 1933. In the case of varieties on which the damage was accurately determined by means of counts of all the fruits produced (i.e. those used in spraying trials) or assessed from counts of random samples of drops, thinnings (if any) and picked crop, the categories adopted in the Table have the following approximate values :

Slight	Less than 10 per cent. of total set affected.
Moderate	10-30 per cent. of total set affected.
Bad	30-50 per cent. of total set affected.
Very bad	Over 50 per cent. of total set affected.

The intensity of attack on the remaining varieties was assessed by means of sample counts of drops and an inspection of the trees in mid-July.

* We are indebted to Mr. M. H. Moore, who made some of the biological observations dealt with in this section, and to Mr. H. C. Chapelow, who provided valuable blossoming data and also facilities for making observations and fruit counts on the " Variety Plot ".

TABLE VI.

Variety.	Full bloom.	Degree of attack.
Clark's Seedling	22nd April.	slight.
†Beauty of Bath	24th April.	slight.
Bismarck	25th April.	slight.
Ribston Pippin	25th April.	slight.
Langley Pippin	25th April.	practically free.
Belle de Boskoop	27th April.	free.
Delicious	29th-30th April.	free.
Gladstone	29th April.	slight.
†Norfolk Beauty	29th April.	slight.
*Early Victoria	1st May.	moderate.
*Cox's Orange Pippin ..	1st May.	moderate—bad.
*James Grieve	1st May.	moderate—bad.
†Allington	?	moderate.
Rival	?	moderate—bad.
*Worcester	2nd-4th May.	bad—very bad.
*Lanes	4th-5th May.	moderate—bad.
Derby	5th May.	moderate.
Edward VII.	7th May.	slight.
*Annie Elizabeth	7th-8th May.	bad.
†Grenadier	8th-9th May.	slight—moderate.
†Newton	8th-9th May.	very bad.
†Crab A.	13th-15th May.	bad.
Mother	15th May.	moderate—bad.
Moss Orchard	16th May.	free.
*Court Pendu Plat	18th May.	moderate—bad.

* Varieties used in spraying trials and of which a complete record of the exact damage was obtained.

† Varieties on which counts were made of random samples of drops, thinnings (if any) and picked crop.

These data agree with the findings of Miles and of Bush in that the *mid-season* were more heavily attacked than the *early flowering varieties*. This is natural, since a greater part of the blossoming period of the mid-season varieties coincided with the active period of the adult sawfly.

In 1933 much of the blossom of the earlier flowering sorts was over before sawflies appeared. Adults were first observed on 28th April, and were abundant by 1st May, when females containing fully developed eggs were first found. Oviposition was first observed on 4th May, on Worcester, and by the next day was at its height.

When oviposition began Bismarck (an early flowering variety) had lost quite 70 per cent. of its petals and therefore ran small risk of becoming infected ; moreover the Bismarck trees were interplanted with Early Victoria, then not much past full bloom and so likely to be more attractive to the sawflies.

As regards the late flowering varieties, these were not much freer from sawfly than the mid-season varieties—in which respect these data agree with a table published by Kearns (10)—and several very late flowering apples (Crab A, Mother and Court Pendu Plat) were *heavily* attacked. A great many adult sawflies were seen ovipositing in blossoms of Court Pendu Plat on 19th May ; many eggs were at the same time found in the blossoms and some of the sawflies were seen in coitu. On the same occasion larvae were found on nearby trees of Langley Pippin and Stirling Castle ; some of these had penetrated the fruits. Other late appearances were recorded as follows: 13th May, one female containing eggs caught on a plot of mixed Bramley and Lanes, 16th May, two females, one containing eggs, taken on open blossom of Crab A.

It seems probable that as the blossom of most varieties became less attractive so the sawflies left them and went on to the late blossoming varieties. If, as Miles states (7), the length of life of the adult sawfly is only six to eleven days it seems likely that the sawflies emerged over a period of at least ten days or so and that the individuals seen on 19th May were some of the later emerged ones.

These observations were made during a season which was, in some respects, exceptional, and it is possible, therefore, that the intensity of attack on the late flowering varieties was also exceptional.

On varieties which are similar in regard to the date and length of their flowering periods the degree of attraction may, as Miles suggests, largely be determined by differences in scent, pollen or nectar.

Summary.

During the course of investigations on the Apple Sawfly carried out in 1933, circumstantial evidence was obtained which pointed to the occurrence of an extra (sixth) instar in larvae which become females.

Larval migration (with consequent secondary attack on the fruits) was found to occur at an earlier stage of larval development than has formerly been supposed. The migrating larvae were controlled to varying degrees by applications of a Derris dust, nicotine and soap, and Derris and soap.

The larvae were found to construct their cocoons chiefly in the top 4 ins. of soil.

Data on relative susceptibility to sawfly attack showed that mid-season were more susceptible than early flowering varieties, but not much more susceptible than late flowering varieties.

References.

(1) Bush, R. G. W. "Despise not Thine Enemy." Fruitgrower, 1933, **75**, 1045.

(2) ——— *Ibid.*, **76**, 90.

(3) Dyar, H. G. "The Number of Moults of Lepidopterous Larvae." Psyche, 1890, **5**, 175-6, 420-2.

(4) Hey, G. L. and Steer, W. "Experiments on the Control of the Apple Sawfly." E. Malling Res. Sta. Ann. Rep. for 1933 (1934), 197-216.

(5) Massee, A. M. "Notes on Insect Pests and Mites in 1932." E. Malling Res. Sta. Ann. Rep. for 1932 (1933), 111-12.

(6) ——— "Entomology." E. Malling Res. Sta. Ann. Rep. for 1927 (I General) (1928), 68.

(7) Miles, H. W. "On the Biology of the Apple Sawfly (*Hoplocampa testudinea* Klug.)." Ann. App. Biol., 1932, **19**, 420-31.

(8) ——— "Growth in the Larvae of Tenthredinidae." Journ. Experimental Biology, 1931, **8**, 355-64.

(9) Theobald, F. V. "Insect Pests of Fruit," Wye, 1909, 122.

(10) Kearns, H. G. H. Paper on "Control of Apple Sawfly" given at the Imperial Fruit Show at Bristol on 2nd November, 1933, and reported in Fruitgrower, 1933, **76**, 811-13.

Section IV

BULLETINS FOR FRUITGROWERS

POMOLOGY

SCION ROOTING AT EAST MALLING RESEARCH STATION*

By R. G. HATTON AND N. B. BAGENAL

WHEN the main apple and pear rootstock trials at East Malling were being planted from 1918 to 1921, the tradition was in full force that apples on " paradise " stocks and pears on quince should be budded as low as possible, and planted with the union below ground level. It was argued that if this was *not* done, an unsightly swelling at the union would result, which in itself would be the cause of additional stunting. Probably also it was felt that with low working there would be less risk of the trees breaking off at the union, although in practice such risk can always be provided for by efficient staking. At that time we were afraid to disregard the tradition altogether, but, realizing the danger of scion rooting, and being anxious to see whether the union swelling would develop above ground, we compromised by planting the trees with the unions at ground level. Unfortunately, the normal cultivations in early years of ploughing up to the tree rows undoubtedly brought the majority of unions slightly below ground level, in spite of the spring " levelling " with the hoe. Three or four years after planting, when we unearthed the original series of Lane's Prince Albert on Number Nine, we had to report that we had merely buried the unions below ground, and that here the swelling at the union was quite as large as is the case above ground. With this variety, however, there was no sign of scion rooting.

Our first suspicions were roused by the fact that several Bramley's Seedling trees among the group on Number Nine suddenly started to grow away much more vigorously than their neighbours, and in 1929, when one of these trees was blown over in a gale, it was found to have been severed from the rootstock and to be completely established on its own roots. This discovery led later to a detailed examination of all the sixteen trees of Bramley's Seedling on Number Nine, at least ten of which proved to be then definitely on their own roots and three more were suspect. The fact that these ten trees now known to be on their own roots are on the average nearly twice as large in cross-sectional area of stem as the trees remaining on Number Nine, means that at the normal planting distance for trees on this stock those which were scion rooted would be already

* Reprinted from the *Kent Farmers' Journal*, June, 1933 by permission of the Editor.

much too close together. Although the total actual crop on these scion rooted trees is, up to the present, actually larger than that from the small trees which are still on Number Nine, this is probably due to the greater bearing surface of the trees, following upon the early " precocity effect " of Number Nine stock. How long this state of affairs will last remains to be seen, but from experiments with trees of one variety planted for comparison on their own roots, on vigorous and on dwarfing stocks, we have evidence to prove that with one exception the own rooted trees were slower to come into bearing than those either on vigorous or on dwarfing stocks (1). This being so, in allowing trees to become scion rooted there is clearly a risk of defeating one of the main objects for which dwarfing stocks are used, namely, to promote early cropping.

Whilst no detailed study of the scion rooting of apples has been made at East Malling, the casual cases that have been noted suggest that two important factors are the type or variety of rootstock and the scion variety. Besides Bramley's Seedling, we have proved cases of Allington Pippin and Laxton's Superb which have scion rooted on Number Nine comparatively early in life, and we have evidence of numerous similar cases in commercial plantations. There are here also definite cases of scion rooting in the varieties Oslin and Grenadier on Number Two and Number Five, and we have suspicions of other varieties on this group of " semi-dwarfing " stock. It seems certain that certain scion varieties very rarely establish themselves on their own roots, even on dwarfing stocks. Out of our whole acreage of Lane's Prince Albert we have no reason to suspect scion rooting, whilst out of a series of 125 trees of fourteen-year-old Worcester Pearmain that were recently grubbed, only two were scion rooted, and these were from a series of eight trees on Number Nine.

If the risk of scion rooting is considerable on stem-worked trees, it is much more so where, as in America, trees are bench-grafted. This fact was first noted here in 1926, when a series of three-year-old apple trees bench-grafted on to piece-roots was lifted for examination. In all cases the scions had rooted so strongly that the original piece-roots had become quite subordinate (2). More recently, one of the writers, when visiting British Columbia, casually came across a number of cases in which the variety Macintosh was scion rooted, and last year when a member of our staff was excavating a series of young bench-grafted trees in British Columbia, with units of trees varying from eight to seventeen, he found that nine out of the fourteen varieties excavated showed scion rooting to a striking degree in their third year.

With pears we have been afforded considerably wider opportunities for detailed observations of scion rooting. As in the case of apples, there is ample evidence to suggest that particular varieties and particular stocks are more prone to the trouble than others. We have found certain varieties scion rooting on the whole range of quince stocks, other varieties show a greater tendency to scion rooting on some quinces than on others, whilst the variety Conference does not appear to become scion rooted on any stock, so far at least as our own trees are concerned.

Early in the life of a series of Fertility, Durondeau, Emile d'Heyst, and Dr. Jules Guyot, we watched the trees on the incompatible stocks D, E, F, and G struggling on without making any appreciable growth for a number of years, or dying out altogether (3). Then suddenly the survivors started into strong growth, and when these were subsequently lifted it was found that they were scion rooted, and that the original quince stocks had been superseded and in many cases were actually dead. It was even more enlightening, however, to find that despite the precautions taken to keep the unions at ground level, even on the compatible types of quince A, B, and C, something like one in three trees were more or less scion rooted. This was particularly the case on Quince C, the very precocious stock corresponding to Number Nine in apples. Out of a

total of 337 trees lifted in the whole series, 156 showed scion rooting to a greater or less degree.

Another rather different but still more striking case of scion rooting in pear trees was revealed when a series of twenty-four Dr. Jules Guyot, ten years old, was recently grubbed. These trees had been double-worked over Quince B in five series, using a different layered pear stock as an intermediate for each series. When lifted it was found that in every case the intermediate had rooted, in seven trees the second scion (Dr. Jules) had also rooted, whilst in ten trees the quince roots were dead.

Our investigations into the behaviour of trees on clonal pear stocks as already reported (4), have shown that at least Dr. Jules Guyot is incompatible on certain free stocks, even from the nursery. Another very suggestive example of this occurred when four trees of Gieser Wilderman on seedling pear were lifted, and showed two trees scion rooted. Amongst other varieties which have now been proved commonly to scion root are Pitmaston Duchess, Doyenne du Comice, and Fondant de Thirriot. Our attention was first drawn to these cases by the very marked change in the habit of growth, even on compatible quince stocks. The trees became noticeably erect and vigorous, with foliage of a dark green colour, the spurs showing less and less fruit bud and an increasingly meagre set of fruit. This type of tree, so frequently to be met with in pear plantations, is often described as a " passenger ", and has even been deliberately avoided by growers when taking buds or grafts in the mistaken belief that it was a " rogue " variety (see Fig. 2). It so happened that we had at East Malling certain rows of pears, in which a single variety was alternately planted on quince and pear stocks. In these rows the behaviour of the " passenger " trees resembled so closely that of their neighbours on pear stock that a detailed survey was made from external characters. Later, when roots of these trees had been exposed, it was found possible to distinguish between the pear and quince roots by the size and appearance of the lenticels, and by microscopical examination of root sections.

We have recently had an opportunity of examining a series of plum trees, consisting of ten varieties on eight combinations of rootstock, and it is interesting that out of some 120 trees lifted only two were found to be scion rooted, and these were on the Brussel, a stock which in our trials has earned such an unenviable reputation for inducing partial incompatibility between stock and scion.

The considerable weight of evidence collected here, under circumstances unpropitious to scion rooting, suggests a possible explanation of some at least of the exceptions to the rule which are to be found in commercial practice ; for instance, while many growers declare that Dr. Jules Guyot will not grow on quince, others have established vigorous trees thereon. This does not mean, however, that it is useless to plant pears on quince or apples on dwarfing stocks because of the risk of scion rooting, but that suitable precautions should be taken to prevent its occurrence.

To meet the situation, two recommendations suggest themselves, one the higher working of trees on the stock stem in order to maintain stock-effect unimpaired, and the other not to plant with the union below ground.

Summary.

Numerous definite cases are cited of apples and pears showing the striking effects of scion rooting, certain varieties and stocks being more prone to this than others. Since scion rooting nullifies the desired stock effect, it is suggested that the old tradition of the low working of trees on the stock stem should be modified, and the practice of planting the union below ground definitely abandoned.

References.

(1) Hatton, R. G. "The Relationship between Scion and Rootstock with Special Reference to the Tree Fruits." Journ. of the R.H.S., Vol. LV, Part 2, 1930, 170.

(2) ——— "Reciprocal Effect of the Scion upon the Root: Part 1, Pomology Section." E. Malling Res. Sta. Ann. Rep. for 1927 (May, 1928), 38.

(3) ——— "The Behaviour of Certain Pears on Various Quince Rootstocks." Journ. Pom. and Hort. Sci., Vol. VII, 224.

(4) ——— "The Relationship between Scion and Rootstock with Special Reference to the Tree Fruits." Journ. of the R.H.S., Vol. LV, Part 2, 1930, 178.

Fig. 1

Pear, Doyenne du Comice (10 years old) on Quince—*not* scion rooted.

Fig. 2

Pear, Doyenne du Comice (10 years old) on Quince—scion rooted. Note erect habit and scanty blossom on this "passenger" tree.

A NOTE ON THE TRAINING OF LOGANBERRIES AND BLACKBERRIES

By A. B. BEAKBANE

INVESTIGATIONS into training methods of loganberries were begun in connection with Mr. R. V. Harris's work on the cane-spot disease, *Plectodiscella veneta* (1). It having been found more difficult to control this disease on loganberries by spraying than on raspberries, it was decided to try and find a method of training which would make it more difficult for spores from the fruiting cane to find their way on to the new cane. This led to the trial of various old and new methods of training and it is thought that a short description of these may be of interest to growers.

Fruiting Cane. In planning a suitable training method, height is one of the most important factors to consider. Except possibly in the case of the very vigorous blackberries, it is unwise to train the plants at a height at which steps would be required for picking, 5 ft. or 5 ft. 6 ins. being usually high enough for the top wire. It is also unwise to train the fruiting cane lower than about 2 ft. 6 ins., first because the pickers in stooping to gather the fruit are liable to upset the tray of berries already picked, and secondly because in a wet season the fruit on the bottom wire would be splashed by rain.

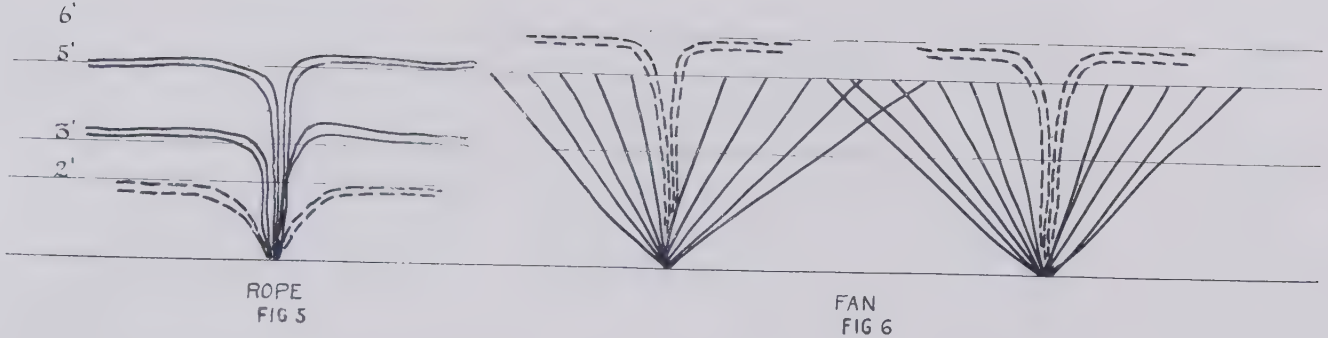
The next question which arises is how to distribute the cane on the wires to the best advantage. In the Fan and Weaving methods, the canes are more or less separated from each other, and are thus exposed to a maximum amount of light and air, but on the other hand the Rope and Alternate Bay methods have a considerable advantage in that less labour is involved in tying the cane to the wires.

Rope Method (see Fig. 5). The cane is tied in four bundles to the wires at 3 ft. and 5 ft. Training in this way is cheap and fairly effective, but it is obvious that the cane will not get so much light and air as in the Weaving or Fan methods described below.

Fan Method (see Fig. 6). The cane is spread out in the shape of a fan and the tops of the canes cut off where they extend above the top wire. Each cane is tied in separately to wires at 3 ft. and 5 ft. Fan training depends for its success on the stimulation of buds on the basal 5 to 7 ft. of cane following the severe cutting back of the canes in training. It is widely used in America but has not yet been tried out in this country. It is therefore being given a preliminary trial in order to find out whether sufficient laterals will be formed, under our climatic conditions, to compensate for the cane which is removed during training.

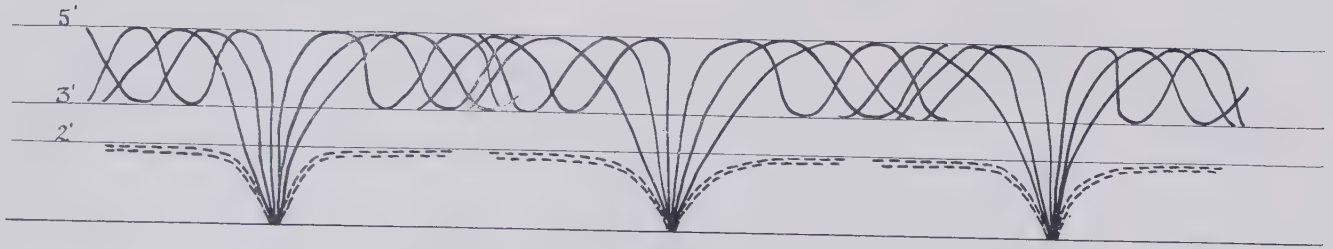
Weaving Method (see Fig. 7). The cane is woven between wires at 3 ft. and 5 ft. All the cane is kept on one side of the wire and looped to the top and bottom wires with string. In the case of blackberries the cane may be crossed over the top wire and under the bottom wire so dispensing with a certain amount of tying, but loganberries are more difficult to train in this way as the cane tends to be brittle.

Alternate Bay Method (see Fig. 8). The cane is tied in three bundles on the wires at 3 ft., 4 ft., and 5 ft., in the same way as for the Rope method except that in this case

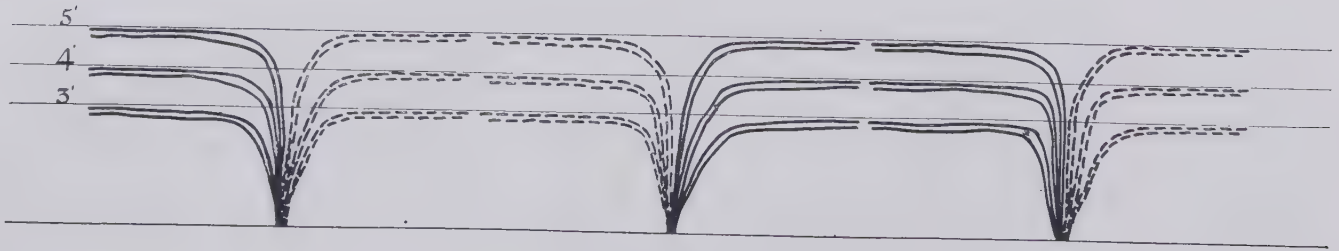


ROPE
FIG 5

FAN
FIG 6



WEAVING
FIG 7



ALTERNATE BAY
FIG 8

FRUITING } CANE
NEW }

all the fruiting cane from one plant is trained in one direction. It is thus possible to keep the young and old cane apart and so help to control the cane-spot disease by limiting the spread of spores from the young to the old cane. The fruiting canes from adjacent plants are trained towards each other, and in this way one bay contains fruiting cane and the next bay young cane which is trained in its permanent position. It is best to alternate the treatments so that the fruiting bay in one row is opposite to the bay for young cane in the next row.

New Cane. The simplest plan is to allow the new cane to trail along the ground, but this has several disadvantages ; it is in the way of cultivation, it is liable to be broken and damaged, and it is lying under the old cane where spores of the cane-spot fungus are likely to fall on to it. The first two disadvantages can be overcome by training the new cane on a wire at 2 ft. above ground level. With regard to the third disadvantage it appears from the one year's records obtained so far, that the spores of the cane-spot fungus usually fall in a vertical direction and do not spread laterally or upwards to the same extent, so that it may be at least partially controlled by keeping the young cane away from the fruiting cane either by using the Alternate Bay Method or by training the young cane *above* the fruiting cane on a 6 ft. wire. In the case of loganberries, however, the possibility of the cane being damaged by cold winds and frosts in a hard Winter must be borne in mind, when training the young cane so high. The various ways of training the young cane may be combined with the different methods of tying in the fruiting cane in several ways besides those suggested in the diagram, for example, when the fruiting cane is woven, the young cane may be allowed to trail on the ground, tied to a wire at about 2 ft. or to a wire at about 6 ft. or woven in one direction only with the fruiting cane woven in the opposite direction, as in the Alternate Bay method.

The need for classification among loganberries has been dealt with in a previous report (2) and it has been shown that, in the present state of affairs, *the word loganberry can only be considered as a group name.* In this connection we are particularly anxious to gain the collaboration of growers, and should be very glad to have our attention drawn to loganberries of good performance, which are distinctive in any way, particularly in regard to health and cropping.

Summary.

Various methods of training loganberries and blackberries are described, and reference is made to the possibility of limiting the spread of the cane-spot disease, *Plectodiscella veneta,* on loganberries by training the young cane away from or above the fruiting cane.

References.

(1) Harris, R. V. " Raspberry Cane Spot : its diagnosis and control." Journ. Pom. and Hort. Sci., 1931, **2**, 73-99.

(2) Beakbane, A. B. " Cultivated Blackberries, Dewberries and Hybrid Berries : A progress report." E. Malling Res. Sta. Ann. Rep. for 1932 (May, 1933), 68-72.

MYCOLOGY

BROWN ROT FUNGI—RECENT OBSERVATIONS ON THEIR INCIDENCE*

By H. WORMALD

THE BROWN ROT FUNGI AND THEIR DISTRIBUTION.

Blossom Wilt, caused by *Sclerotinia cinerea*, one of the Brown Rot fungi, was responsible for great damage to fruit crops in this country, in 1932, and the numerous enquiries that were received about the Brown Rot diseases, from commercial growers and private owners of fruit trees, are a proof that there are still many growers who do not recognize the true nature of these diseases and the losses that may be incurred by neglecting them.

It seems opportune, therefore, to bring to the notice of readers of this journal a general account of certain investigations and observations made in recent years on diseases caused by the Brown Rot fungi, particularly as the articles in which some of these observations have been recorded are not readily accessible to the general reader.†

In Britain and on the Continent there are two species of brown rot fungi, *Sclerotinia* (*Monilia*) *fructigena* and *Sclerotinia* (*Monilia*) *cinerea*. The brown rot fungus of the apricot is sometimes referred to as *Sclerotinia laxa* but as it is indistinguishable from *S. cinerea* it is included in the latter. The perfect or ascigerous stage (*Sclerotinia*) of these fungi is of rare occurrence and it is the *Monilia*, or conidial stage that is important in causing epidemic outbreaks of infection.

Sclerotinia fructigena is the common brown rot fungus found on apples and pears. It is most conspicuous on the ripening fruit, but it may attack the fruit at all stages from soon after the fruit is set, and it also causes a " black rot " of apples in the store. The same fungus causes fruit rot of cherries and plums also.

Sclerotinia cinerea, although it, too, produces a fruit rot of cherries, plums, peaches, and occasionally pears and apples, is chiefly harmful because it infects the flowers and so causes blossom wilt. In blossom wilt one or more flowers of a cluster become infected and the fungus extends from these primarily infected flowers into the axis of the spur bearing them and so causes all the blossoms on that spur to wilt, together with the accompanying leaves, if present. In many cases the fungus proceeds further, into the twigs or branches, to form cankers, which, when they encircle the branches, cause the

* Republished by courtesy of the *Fruitgrower*, 17th and 24th August, 1933.

† *Sclerotinia fructigena* as the Cause of an Apple Canker. *Trans. Brit. Mycol. Soc.*, XV, 102-7, 1930.

Brown Rot Blossom Wilt of Pear Trees. *Ann. Bot.*, XLIV, 965-74, 1930.

Brown Rot Blossom Wilt of the Morello Cherry : Infection through unopened Flowers. *Journ. of Pom. and Hort. Sci.*, IX, 232-7, 1931.

Blossom Wilt in Fruit Trees. *Journ. Min. Agric.*, XXXIX, 620-6, 1932.

The distribution of the Brown Rot fungi is discussed in the *Annals of Botany* (XLI, 287-99, 1927) and in the *Journal of the Ministry of Agriculture* (XXXV, 741-50, 1928).

death of those parts above them. This blossom wilt fungus has been shown to comprise two " biologic forms ". One of these produces blossom wilt in cherries and plums and the other is the cause of blossom wilt and brown rot canker in apples.

Sclerotinia fructigena appears to be almost confined to Europe. It has been authentically recorded for Japan and Manchuria but up to the present it has not been found in the great fruitgrowing regions of America, Australia and New Zealand, although in these areas there exists another brown rot fungus.

S. cinerea is found in Europe (including the British Isles) and in certain regions in North America bordering on the Pacific Ocean, viz. Oregon, California, and Vancouver Island. It has not yet been recorded for Australia or New Zealand.

Generally distributed throughout the fruitgrowing regions of North America is a brown rot fungus, known as *Sclerotinia americana* (called by some investigators *S. fructicola*) which is closely related to *S. cinerea* but distinguished from the latter by certain cultural characters. It is particularly a fruit rotting fungus (though it also infects flowers) and is very destructive to peaches. This fungus is identical with the one responsible for brown rot of stone-fruits in Australia and New Zealand. It sometimes infects apples, but as a parasite of the core-fruits it is not of great importance. So far as our present knowledge goes it may be stated then that neither *S. fructigena* nor *S. cinerea* is present in Australia or New Zealand. On the other hand *S. americana* does not occur in Britain or on the Continent.

A knowledge of the geographical distribution of the brown rot fungi is of some economic significance, for, as indicated above, their mode of parasitism is not identical. Thus *S. fructigena* is especially destructive in causing fruit rot of apples and pears, *S. cinerea* is chiefly a blossom wilt fungus, while *S. americana* is particularly a fruit-rotting fungus of stone-fruits and causes comparatively little damage to apples and pears. The importance of preventing the general distribution of all three fungi is obvious. For example, the introduction of *S. fructigena* into the apple-growing regions of North America, New Zealand and Australia would doubtless have an adverse effect on the quality and quantity of apples exported from those regions. Again, the fact that the American brown rot fungus has been found on imported fruit suggests that one day it may become established in this country unless precautions are taken to prevent infected fruit from entering our ports.

Blossom Wilt in 1932.

The severe outbreaks of blossom wilt during the Spring of 1932 in apple, plum and cherry plantations in various parts of England was one result of the cold wet weather that was experienced about the period the trees were in flower. Such conditions were favourable for the development of the blossom wilt fungus and at the same time delayed the setting of the fruit so that the flowers remained open, and therefore liable to infection from the fungal spores, for a relatively long period. Except on Morello cherries brown rot infection in 1931 had not been particularly severe and little notice was taken of it, with the result that sufficient sources of infection (mummified fruit and dead spurs and twigs) were left on the trees to produce damage on a large scale under the conditions which obtained in the Spring of 1932.

Blossom wilt had not been so severe on apple trees for about twenty years. On sweet cherries great damage was caused in north Kent and on some large standard trees about half the blossom was destroyed. Some varieties of plums also showed very severe infection ; in a plantation of President plums near Canterbury practically all the blossom was destroyed and an adjoining plot of Czars was almost as bad.

Apple Blossom Wilt.

This disease was investigated in this country in 1916 and 1917 when there were serious outbreaks, particularly in the south of England. It was assumed at first that blossom wilt of apple trees was caused by *S. fructigena*. During the course of the investigation it was found, however, that blossom wilt was not induced by *S. fructigena* but by *S. cinerea*, and it was shown also that the form of *S. cinerea* on apple trees was biologically distinct from that on plums and cherries from the fact that the fungus isolated from plums and cherries when inoculated into apple flowers did not produce blossom wilt. The apple blossom wilt fungus is therefore designated *Sclerotinia cinerea* forma *mali* while that which infects plum and cherry trees is referred to as *S. cinerea* forma *pruni*.

As shown later, *S. fructigena* may cause cankers on apple trees but the damage caused by this fungus to the spurs and branches has never proved so serious as that which follows blossom infection by *S. cinerea*.

Between 1917 and 1932 there were no very serious complaints about the ravages of this disease and apparently there had been a little infection each year without causing undue alarm. In 1932, however, it appeared in increased intensity and in some plantations (particularly of Lord Derby apples) more than half the blossom was destroyed. In fact in some instances infected plantations could be recognized at a distance by reason of the brown withered flowers and foliage.

Infection takes place by spores falling into the open flowers. When one flower of a cluster becomes infected the fungus kills that flower, passes down the flower stalk into the axis of the inflorescence and then the whole truss of flowers and leaves flags, turns brown and withers. The wilting of the trusses occurs about a fortnight after the flowers open, and experiments have shown that the fungus takes about that time to traverse the distance from the stigma of an infected flower to the tissues of the spur.

Generally the fungus is not visible on infected flowers during the Summer, although it is sometimes observed on dead flowers and flower-stalks in very wet weather. From the spurs the fungus may pass into the branches, or into the main stem in cordon trees, to produce cankers. When a canker encircles a branch or stem the parts above the canker are killed.

The fungus passes the Winter within the tissues of the cankers and the dead spurs ; in the following year it comes to the surface and produces its Monilia fructifications in the form of grey velvety tufts. These fructifications develop numerous spores which are dispersed by the wind and when the blossoms open in Spring some of the spores fall into them and infection occurs again. Thus the spurs and branches infected one year become sources of infection during the following year.

It follows, therefore, that the most rational method of keeping the disease in check is to cut out all infected spurs and cankers. The best time to do this is in Summer immediately the wilting is observed for the brown withered trusses are easily seen. This cutting out of infected parts may be carried out in Winter but the dead spurs are not so readily recognized as in Summer, although, as a rule, they can be distinguished because some of the dead flowers and fragments of the leaves persist on the infected trusses through the Winter. In any case such potential sources of infection should not be allowed to remain on the trees until Spring.

Trees of those varieties particularly susceptible to blossom wilt should be examined each year, even in years of little infection, and all diseased parts cut away. One well-known Kentish fruitgrower, whose Lord Derby trees were heavily infected in the epidemics of 1916 and 1917, was advised along these lines and since that time he has had his trees examined systematically each year and infected spurs and cankers removed,

with the result that in recent years his losses from blossom wilt have been negligible, even in 1932 when blossom wilt was so prevalent.

Pear Blossom Wilt.

This disease appears to be comparatively rare in this country. In 1920 I received a truss of withered pear flowers (the variety was not ascertained) from Cambridgeshire, bearing the Monilia fructifications of *Sclerotinia cinerea*. In the following year blossom wilt was observed on Fertility pear trees at Wye, Kent, and again the same fungus was present. Spurs were killed but the fungus had not extended into the branches to form cankers. Most of the dead spurs were pruned away during the Winter, but a few were overlooked and so were left on the trees; in February, 1922, these dead spurs bore Monilia fructifications. The trees were kept under observation and in May after the trees had come into bloom several of the inflorescences on two of the trees showed typical blossom wilt, the flowers being infected presumably by spores produced by the fungal fructifications on the old dead spurs.

The disease was not observed again until 1925 when specimens (again from Fertility pear trees) were received from Sussex. It was estimated that each tree had from seventy to eighty dead trusses of flowers, the trees being 6 to 8 ft. high.

Inoculation experiments were carried out during the years 1924 to 1929, to ascertain whether the fungus really could infect pear flowers. In the earlier attempts the inoculations yielded inconclusive results but during 1928 and 1929 positive results were obtained. Spores of the fungus, taken from pure cultures, when placed on the stigmas of pear flowers not only resulted in the death of an inoculated flower but the fungal hyphae extended into the tissues of the axis of the inflorescence and the whole truss of flowers and leaves on that spur withered, a condition typical of blossom wilt. The progress of infection could easily be traced by the blackening of the tissues as the fungus advanced. In these experiments the infection process proceeded very slowly for some days and about a week was required for the spores to germinate and the hyphae to grow down the tissues of the styles to the centre of the flower. After this, progress was more rapid and the fungus grew downwards within the flower stalk towards the spur at the rate of about 1 cm. per day and the rest of the flowers on the spur together with the leaves surrounding them began to flag about the eleventh day after inoculation of the stigmas.

The habits of the pear blossom fungus when growing in pure culture are more like those of *S. cinerea* as found on plums and cherries (forma *pruni*) than those of the apple blossom wilt fungus (forma *mali*) so inoculations were carried out on pear flowers using strains of the fungus isolated from a plum twig and from a cherry. The results were similar to those obtained with the pear strain itself and show that infected plum and cherry trees may serve as sources of infection for pear flowers.

Pear blossom wilt has been recorded in this country, up to the present, only on the variety Fertility and it is not known what other varieties are susceptible to this disease. There are two other diseases of pear blossoms that have similar general symptoms. Bacteria sometimes infect the flowers, blackening and killing them. Pear scab, too, may infect the spurs severely enough to cause the flowers to wither.

Blossom Wilt of Morello Cherries.

The Morello, a well-known fruitful culinary cherry often grown in gardens and frequently cultivated on a larger scale in plantations, is liable to be very heavily infected by *Sclerotinia cinerea*. Rarely a season passes without complaints of loss, and in some seasons neglected trees may have all, or nearly all, their blossom destroyed.

The disease was very prevalent in 1931 and a brief reference to the outbreak that year has already appeared in the *Gardeners' Chronicle* (12th March, 1932, p. 208), but as the disease is of interest to gardeners and private owners as well as commercial growers, and as it is still far too common considering that it can be kept under control with reasonable attention, a more detailed account is called for.

In the Morello cherry the flowers are borne in clusters (umbels) at the nodes of the one-year-old twigs. Thus when a flower becomes infected the fungus on reaching the base of the flower stalk passes directly into the twig, the tissues of which become infected for some distance above and below the infected node, and the whole of that portion of the twig above the infected region withers in consequence. It follows that when infection occurs at one of the lower nodes on a twig, all, or most of the blossoms on that twig are killed either by direct infection or indirectly by the fungus cutting off the upward flow of sap.

In blossom wilt of fruit trees infection generally takes place through the open flowers, but in the Morello, if the weather conditions are particularly favourable for the fungus, severe infection may occur while the flowers are still in bud. In 1924 I observed *S. cinerea* on unopened Morello flowers suggesting infection at that stage, and in 1925 by inoculating flower buds with spores under greenhouse conditions I found that the unopened buds could be infected and killed, but it was not known until 1931 that such infection may sometimes occur on a large scale. Early in May of that year, it was observed, on a plot of Morello trees at the East Malling Research Station, that many twigs were dying and on examining these it was seen that at the base of each dead portion there was a cluster of dead flower buds bearing Monilia fructifications.

These dead twigs were cut off but about a fortnight later other twigs were found to be withering. This time at the base of each dead portion there was a cluster of dead open flowers bearing the fungus. Thus in that year infection occurred on Morellos at two periods, one when the flowers were in bud, the other while the flowers were open.

Specimens received from other localities showed a similar condition so it would appear that in 1931 brown rot infection of unopened Morello flowers was not uncommon. In 1932, although there was considerable damage due to infection of open flowers no instance of damage to the flower buds was observed.

An Apple Canker Caused by *Sclerotinia fructigena*.

The common fruit rot fungus *S. fructigena* primarily infects the fruit only. It is not known to infect the flowers and thus is unlike the related species *S. cinerea*, which, as already shown, is the cause of blossom wilt. From the fruit, however, it may advance into the spurs and even into the branches to form cankers ; recent observations have shown that the cankers caused by this fungus, on trees of certain varieties of apples, may girdle branches and kill them.

That severe cankering may follow fruit infection by *S. fructigena* was observed at East Malling in 1928 on a variety of apple known as Melon. On three trees of this variety about 40 per cent. of the fruit became infected with brown rot. From some of these infected fruits the fungus extended into the branches producing cankers which resulted in the death of some of the " leaders ".

Similar cankers have been found on other varieties of apples, e.g. Cox's Orange Pippin, James Grieve, Cutler Grieve, Devonshire Quarrenden, Lord Lambourne, Stirling Castle, Lord Derby, and Laxton's Superb.

In February, 1933, the upper portion of a branch of a Cox's Orange Pippin tree was brought to me with a girdling canker 4½ ins. long. No fungal fructifications were

present at the time but, on keeping the canker in a moist chamber for a few days, fructifications of *Monilia fructigena* appeared, showing that the fungus was hibernating in the tissues of the canker. Normally the fructifications would not have appeared until about three months later.

Such cankers, resulting from infection in late Summer, have been kept under observation in the open and it has been found that in the following Spring (usually during May) the fungus resumes development and spore-bearing fructifications appear on the surface of the cankers which thus serve as sources of infection for the new apple crop.

Control Measures.

Those parts of fruit trees which are infected with the brown rot fungi become permeated with mycelium. The fungus passes the Winter in the infected organs and then produces a new crop of spores which serve to start a new outbreak the following year. The most effective method of dealing with these fungi consists, therefore, in the destruction of such sources of infection. Mummified fruit, dead twigs and spurs, and cankered branches should be removed from the trees and burnt.

The ideal time for cutting out twigs and spurs, which have become infected as a result of blossom wilt, is immediately the blossom wilt is noticed. The wilted trusses are then most easily seen and in some cases (as in apple blossom wilt) the infection may be prevented from extending in the branches. If the operation is left over until Winter the dead spurs are not readily detected although they can usually be recognized by the dead flowers and leaves which often persist on them into the Winter. In any case all sources of infection should be removed before the trees come into flower again.

Spraying against brown rot of the fruit is not practised in this country although in America several sprayings are usually found to be necessary for stone-fruit trees (cherry, plum, peach) as a protection against fruit rot. Blossom wilt, however, is the chief trouble in our own country and spraying to protect the flowers from infection has been tried, usually not with very great success. In some instances a certain measure of control has been obtained by winter washes, e.g. by tar-oil or by a caustic wash consisting of 1 lb. of soft soap and 1 lb. of caustic soda in 10 gallons of water ; such washes are applied with the object of destroying, or rendering sterile, the fungal fructifications which develop on those parts of the trees that were infected the previous year. Promising results have also been given by Bordeaux mixture and lime-sulphur applied as the trees come into flower.

In general it may be stated, therefore, that the best results are obtained when the sources of infection are removed and destroyed ; such measures should be adopted without fail on trees that do not attain to any great size, such as Morello cherries and bush or half standard apple trees. On large standard trees such measures cannot easily be carried out for obvious reasons, and spraying will usually be necessary. If it is recognized, however, that a slight infection one year may leave sufficient infected material on the trees to cause great damage the following season if conditions are favourable for the development and dissemination of the parasite, and if care is taken to remove such infected parts in seasons of little infection when the operation will not be a very difficult one, then epidemic outbreaks will be avoided. When spraying has to be resorted to for the control of blossom wilt one of the winter washes mentioned should be tried or the trees should be sprayed with either Bordeaux mixture or lime-sulphur just before the trees come into flower.

ENTOMOLOGY

THE WARM WATER TREATMENT OF STRAWBERRY PLANTS

By A. M. MASSEE

ALTHOUGH it is not suggested that such pests as the Strawberry Tarsonemid Mite, the Strawberry Red Spider and the Strawberry Aphis are wholly responsible for the degeneration of the strawberry plant, it is a considered fact that they are associated with some of our main strawberry problems. Therefore it can be assumed that their presence is detrimental to the plant, and any means possible to eradicate them should be practised.

Experiments have shown that these pests can be destroyed by treating the strawberry plants in warm water, for a given time, at a constant temperature.

The warm water treatment of strawberry plants has now passed the experimental stage, and is being used by practical growers in many parts of Kent.

Particulars of the treatment are as follows :

The strawberry runners should be sterilized in warm water, at a constant temperature of 110° F. for a period of twenty minutes. This can be carried out in the field without any elaborate apparatus.

In Kent, a number of commercial growers have sterilized their plants successfully in a galvanized tank. The tank should be let into the soil (the best situation being the side of a hill) leaving sufficient space underneath it for the fire, and the flue and chimney should be erected at one end. The fireplace under the tank should run the whole length of the tank. In fact the whole concern very much resembles a creosote tank used by many growers for steeping hop poles. It should be remembered that the temperature can be kept more constant in a large tank than in a small one.

The water should be heated to a temperature of 112° F. This is 2 degrees above the required temperature, but as soon as the plants are placed in the water the temperature drops about 3 or 4 degrees to 108° F. Then the temperature should be raised again as soon as possible by stoking the fire under the tank. Old apple trees and prunings have been found suitable fuel. In practice it has been found convenient to contain the plants in cauliflower or sprout nets rather than put them loose into the tank.

Also the treatment will be more successful if the plants are put into the tank loose, and not tied up tightly in bundles.

It must be emphasized that the temperature must not be allowed to reach 115° F. *or the plants will be killed. Conversely the temperature must not fall below* 108° *F. or the mites and their eggs will not be destroyed.*

The plants should be submerged in the warm water for a period of twenty minutes, and then they should be taken out as soon as possible. On removal they should be cooled off as quickly as possible. This can best be done by plunging them into cold water. If the plants are tied up in bundles at the time of treatment, the bundles should be cut directly they are removed from the tank, and the plants should be spread out to cool off. It is important to remember that the plants must not be allowed to over-heat after treatment, since this has proved to be one of the chief causes of mortality of the plants.

Directly the plants have been cooled off they are ready for planting out.

Experience has shown that the plants can be sterilized at any period of the year, but the months from October to the end of February should be avoided since if they are planted at this time of the year very little growth, if any, is made, and some of them are sure to perish.

Specially made apparatus is available for sterilizing the plants, but the tank method described above is very efficient, provided a reliable thermometer is used to obtain the correct water temperature.

The grower who is going to sterilize plants for the first time will be well advised to experiment in the first instance by sterilizing turnip tops or other waste produce in order to determine whether the correct temperature can be maintained with the apparatus available.

The varieties Royal Sovereign, Stirling Castle, Stirlingworth, King George, The Duke, Laxton and Oberschlesian can be treated without loss of plants. Other varieties have not been tested so far on a large scale, but it appears likely that many of them will also stand the treatment without ill effect.

Summary.

A method of sterilizing plants in warm water for the eradication of certain pests of strawberry is described.

It is shown that the method can be used by the grower provided certain simple rules are carefully observed.

APPLE SAWFLY—SOME SUGGESTIONS FOR CONTROL MEASURES

By G. L. HEY, M. H. MOORE AND W. STEER

THE results of experiments carried out in 1933 on the control of Apple Sawfly are given in some detail in Section III of this report. The following notes are intended, not as definite recommendations, but as suggestions likely to be of immediate help to growers. It will not be possible, of course, to give final recommendations until the experimental results are confirmed by further research. For this reason also, no departure from the existing standard recommendation was made in compiling the spray-calendar issued by this Station in December.

SUGGESTIONS.

Spray with nicotine at any time from petal-fall (i.e. when about 80 per cent. of the petals have fallen) to about a week afterwards.

(1) *Most Varieties.* Add the nicotine at the rate of 8 ozs. per 100 gallons to the lime-sulphur Scab spray *applied at petal-fall*. Add also a suitable wetter and spreader (*not* soap) and spray the trees heavily. Hence, to avoid the risk of spray-injury, it may be advisable to reduce the strength of the lime-sulphur from 1 gallon to 6 pints per 100 gallons. If desired, lead arsenate paste can also be added, but its inclusion in an "omnibus" wash which contains nicotine is not necessary as far as Sawfly is concerned.

(2) *Sulphur-shy Varieties.* Many of these normally do not require any post-blossom treatment for Scab, and may be sprayed with nicotine (8 ozs.) and soft soap (8 lbs. per 100 gallons). Since fruit-russeting may follow the use of soap on trees already sprayed (at pink-bud) with lead arsenate, an alternative wetter is advisable.

If Bordeaux mixture is used for Scab, the nicotine and a suitable wetter may be added to it. Then, the amount of copper used might wisely be reduced from 8 lbs. to not more than 6 lbs. per 100 gallons to avoid spray-injury.

The object of a *petal-fall* application for Sawfly is to kill the eggs and so to prevent infestation of the fruits. If, for any reason, this spray is omitted, some loss can still be avoided. Examine the trees about a fortnight after petal-fall and, if tunnels under the skin or holes in the sides of the fruitlets are seen, apply a Derris dust immediately to protect the remaining uninjured fruits. If the dust is washed off by rain within ten days of application, then dust again.

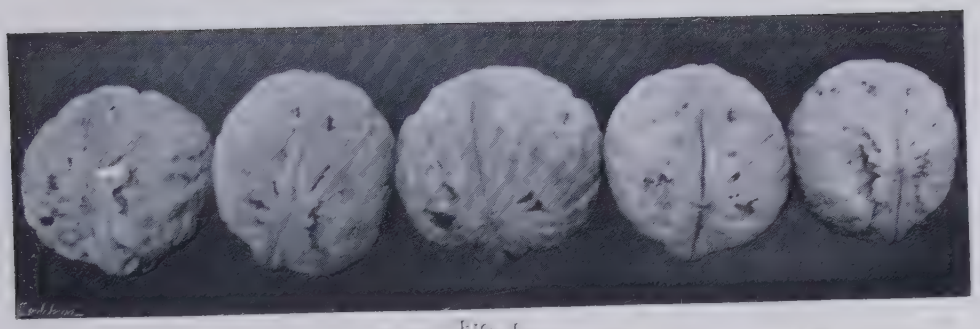


FIG. 1.

Walnuts showing imperfectly ripened shells, after the wet summer of 1931.

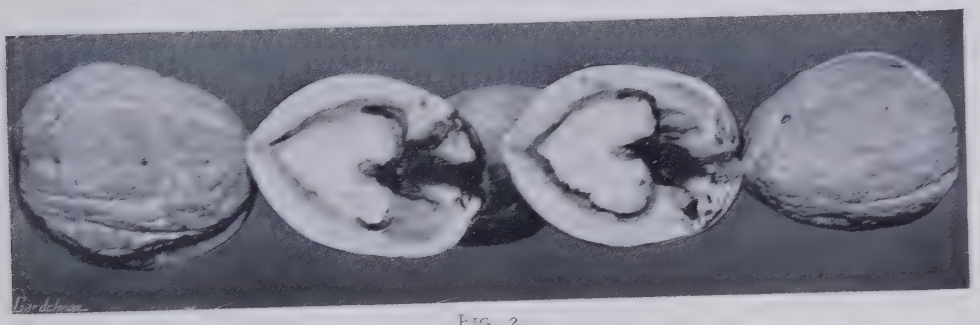


FIG. 2.

Bleached walnuts stored in a mixture of salt and coco-nut fibre. Photograph taken in May 1933.

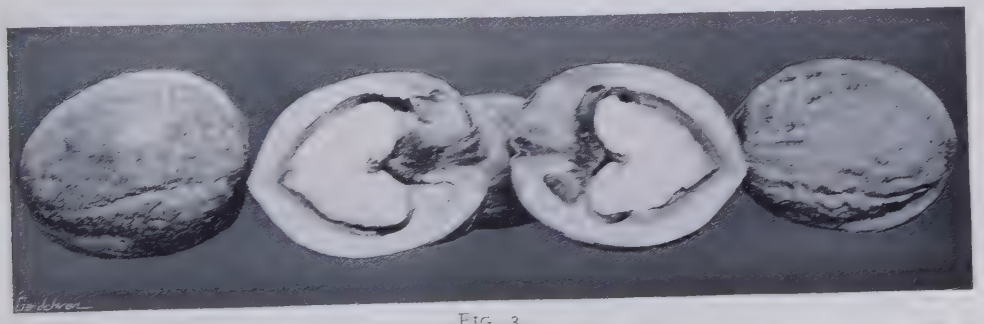


FIG. 3.

Walnuts stored in a mixture of salt and sodium phosphate. The shells were cleaned, but otherwise untreated before storing.

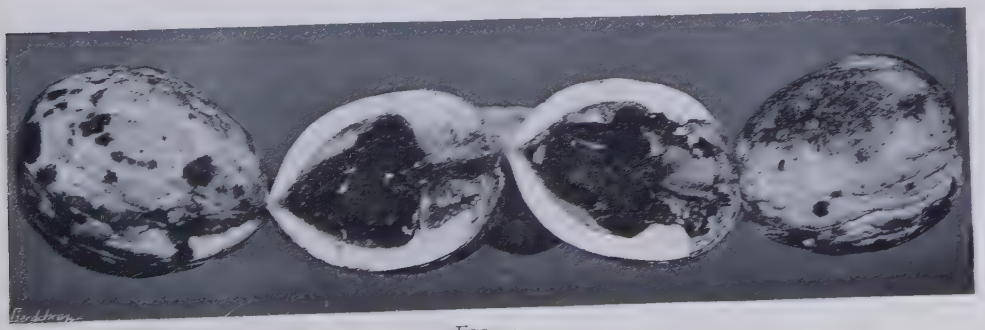


FIG. 4.

Bleached walnuts stored without any storage medium.

GENERAL

SOME RECENT INVESTIGATIONS INTO METHODS OF STORING WALNUTS DURING THE WINTER*

By J. B. HAMOND

THE present remarks on the storage of walnuts during the Winter, are the result of observations made during experiments carried out at East Malling Research Station during the last three years. These recommendations will be confined to " fresh ", as opposed to " dry " nuts. In America, where walnuts are grown on a large scale and used in enormous quantities for confectionery, several types of mechanical driers are in use (1). These operate at temperatures between 100°-110° F., and slowly eliminate moisture from the nuts in a current of briskly circulating air. The dried nuts, although richer in flavour and easier to keep free from moulds, lose much of the attractive crispness of fresh nuts, and hence the latter are generally preferred for dessert purposes in this country.

HARVESTING THE NUTS.

Walnuts are harvested from the ground during September and October. It is important to remove the green outer husk immediately it is ready to fall away from the nut, otherwise it quickly becomes black and difficult to remove, leaving a discoloured shell beneath. When the nuts are ripe the tree should be shaken with long poles at frequent intervals, it will then be found quite easy to remove the shucks from the nuts which fall.

After the shuck has been taken off, fibres of it will still be found adhering to the crevices of the shell. These must be removed, as it is here that spores of numerous saprophytic fungi commence to grow. These moulds quickly pass between the two halves of the shell and attack the kernel within. In microscopic sections, strands of mycelium have been seen actually passing from a trace of shuck on the outside of a shell, and thence between the wood fibres of which the shell is composed, finally reaching the kernel. Where nuts are grown on a large scale mechanical washers are used to rid the crevices of the shells of every trace of shuck. In these experiments this has been accomplished quite successfully with a soft scrubbing brush and water. The nuts must not be allowed to remain in contact with the water for more than a few seconds otherwise they tend to crack open along the line of sealing of the two halves of the shell. After washing, the nuts are dried in a single layer at room temperature, preferably in a current of air, so that the water is rapidly evaporated without the application of heat, as a sudden increase in temperature also brings about cracking of the shells.

BLEACHING AND OTHER SHELL TREATMENTS.

When dry, it is advisable to treat well-sealed nuts with a bleaching solution. This not only improves the appearance of the nuts, but makes the shells more resistant

* Reprinted from the *Gardeners' Chronicle* (16th September, 1933) by permission of the Editor.

to attacks by moulds. Various bleaching solutions have been tried during the course of these experiments, and of these a solution prepared from chloride of lime and adapted from a formula suggested by Wiegand (1) has proved the most effective. This solution can be made easily and cheaply as follows :

3 lbs. of chloride of lime are placed in a 5 gallon container, and mixed into a creamy paste with a little water. About 2 gallons of water are added and the mixture is stirred thoroughly. 1½ lbs. of washing soda is dissolved in water in another container, and this solution is poured into the chloride of lime suspension. Water is added to make a total volume of 5 gallons. After stirring, the mixture is left to settle for at least twenty-four hours. The clear supernatant liquid is then poured off and is ready to be used for bleaching.

Walnuts are transferred to this bleaching solution, and kept in contact with it for about three minutes. They are then drained and dried again in a single layer at room temperature.

Solutions of sodium sulphite and sodium hypochlorite to which acid had been added to liberate the free sulphur dioxide and chlorine respectively, were also used in bleaching experiments. In neither case were the treated nuts so light in colour as a similar sample treated with a bleaching solution prepared as above. Nuts treated with sodium sulphite developed traces of mould on the shells after storing until January, whereas nuts treated with the chloride of lime preparation and stored under similar conditions remained free from moulds until the experiment was terminated at the beginning of May.

Other walnuts have been treated with various fungicides in order to prevent the growth of moulds and not necessarily with a view to improving the shell appearance. Experiments in this direction have not been successful. Nuts dipped in a solution of copper sulphate became attacked by moulds after they had been stored for two months only, under conditions in which bleached nuts remained clean. Not only was the appearance of these nuts not improved, but the shells were definitely darkened by the fungicide. Similar results were obtained by treating walnuts with a 5 per cent. solution of borax before storing. Nuts dipped in a solution of common salt which was saturated at a temperature of 60° F. also developed moulds under conditions in which bleached nuts were unattacked.

Dusting the nuts with sulphur before storing had an excellent fungicidal effect, the nuts remaining free from moulds until the experiment was terminated in May. The difficulty connected with this treatment was to rid the shells from sulphur before the nuts were eaten. However carefully this was attempted, a few particles of sulphur were very liable to alight on the kernels when the nuts were cracked, and ruin their flavour. In view of this trouble, added to the much impaired appearance of the shells, sulphur treatment is not recommended.

Another line of experiment has been to dip the nuts in melted paraffin wax before storing them. The wax was heated sufficiently to melt it, the nuts were placed in a wire basket, which was immersed in the wax, shaken and rapidly withdrawn. When the nuts were spread out on paper the wax congealed almost immediately, forming a thin semitransparent coating over the shells. Nuts so treated presented a curious but not unattractive appearance.

Although the kernels of these nuts were as plump and " milky " at the end of April as when put into store, they developed a peculiar flavour by the end of January, which made them useless. Presumably the deterioration in flavour was connected with imperfect respiration due to an airtight film of wax.

Summing up these various shell treatments, therefore, bleaching in a solution prepared from chloride of lime and washing soda is the only one to be recommended.

It is obviously important that only nuts which are well-sealed after the preliminary washing in water should be bleached, as a drop of bleaching solution inside the kernel will make it unfit to eat. In these experiments it has been found impossible to store badly-sealed nuts with much success, although this may be attempted for a few months. Such nuts quickly become shrivelled or allow ready access to moulds. The same applies to walnuts in which the shells are only partially ripened (2). This trouble was very prevalent after the wet Summer of 1931 when many samples of nuts were received in which the shells were incompletely formed, leaving holes or thin places at the apices of the nuts (Fig. 1). Except in the rare cases where this trouble is varietal, walnuts with incompletely ripened shells have only been recorded after abnormally wet Summers.

PLACE OF STORAGE.

As noticed in an earlier paper (3), when deciding upon a suitable place in which to store walnuts, two factors must be considered. Firstly, the relative humidity of the atmosphere, and secondly the temperature. The correct balance of these two factors should retain the plumpness of the kernels while discouraging the growth of moulds. It has been found that under cold storage conditions, i.e. at a temperature of 38° F. and a relative humidity of about 90 per cent., bleached and unbleached nuts keep plump and free from moulds without any storage medium.* If the temperature is raised to 45° F. and the relative humidity is kept at 90 per cent., these being average readings in a cellar during the Winter, the kernels do not shrivel appreciably, but a storage medium is required to keep even bleached nuts free from moulds. If the relative humidity of the atmosphere is lowered to between 70 and 80 per cent. and the temperature is kept at about 45° F., the nuts are found to shrivel badly, but they are very little attacked by moulds, even in the absence of any storage medium. As cold storage conditions are not usually available, the problem has been to find a suitable medium in which to keep nuts under conditions similar to those of a private cellar, in contrast with the comparatively simple problem of keeping them fresh and free from fungi in cold store.

STORAGE MEDIA.

When trying out a storage medium the method adopted has been to fill large, clean earthenware pots with alternate layers of nuts and the medium. Each month, from November until May, nuts were taken at random from each pot and examined for freedom from moulds, appearance, plumpness, and flavour. During the last three seasons a number of different storage media have been tried out including sand, coco-nut fibre, sawdust, sphagnum moss, peat-moss fibre, and common salt. Some of these were quickly eliminated on account of the difficulty of ridding the shells from particles of the medium, this was notable where sand or peat-moss fibre were used. Sphagnum moss, although good from a fungicidal point of view, imparted a slight, but definite detrimental flavour to the nuts. In these experiments salt has been found to be by far the best fungicide used. It has the disadvantage, however, of absorbing moisture from the atmosphere, with the result that the nuts become damp and crack open along the line of sealing of the two halves of the shell.

During the Winter 1932-33 several attempts were made to counteract the effect of moisture absorbed by salt when used as a storage medium. Firstly, as mentioned above, when dealing with shell treatments, the nuts have been dipped in a saturated salt solution before storing. The result has been that nuts so treated showed moulds on their shells by January, whereas a similar sample surrounded by solid salt remained

* The writer is indebted to Dr. West for permission to make use of the Ditton Laboratories in these experiments.

free from moulds until May. In the other methods salt has been mixed with coco-nut fibre or sodium phosphate ($Na_2 HPO_4 12 H_2O$), both of which absorb moisture, and so tend to counteract the deliquescent properties of the salt.* A mixture of 90 per cent. salt and 10 per cent. sodium phosphate has been effective in keeping bleached nuts well-sealed and free from moulds. Although uncracked, the nuts were slightly damp at the termination of the experiment. Probably if the salt and sodium phosphate were more intimately mixed, even this dampness could be overcome. A mixture of salt and coco-nut fibre in the proportion of 1 : 1 by weight was an excellent storage medium. Bleached nuts surrounded by this medium remained well-sealed and free from moulds from October until the termination of the experiment in May (Fig. 2).

A point which has been noticed throughout these experiments is that, under cellar conditions, the medium in which the nuts are stored is of more importance than any shell treatment after the nuts have been cleaned and before they are stored. This may be illustrated by the following example. Nuts that were cleaned with water and placed in a mixture of salt and sodium phosphate, without previous bleaching, kept plump and free from moulds until the end of May and, apart from their darker colour, were as good as those that had been bleached before storing in the same medium (Fig. 3). When, however, two similar samples of nuts were treated with the same bleaching agent, and one lot were stored in salt and sodium phosphate, while the other lot were kept without storage medium, moulds appeared on the latter in December, after two months only, and eventually penetrated the kernels (Fig. 4) while the former remained clean until the end of May.

In the seasons 1930-31 and 1931-32 all the experiments were carried out in duplicate, using nuts known to have an exceptionally high oil content in comparison with an average sample. Throughout these trials it was noticed that the nuts of the average sample deteriorated more rapidly than those of high oil content. Grafted trees from varieties known to bear nuts of high oil content are being raised at this Station, and the problem of keeping English walnuts fresh during the Winter will be greatly simplified, as these trees become widely planted up and come into cropping.

Summary.

The importance of removing every trace of the green, outer husks as soon as the nuts are ripe is stressed. This operation minimizes infection by saprophytic moulds. Various shell treatments are dealt with, including a successful method of bleaching the nuts, which is given in detail.

Important factors in selecting a suitable place of storage are mentioned and the question of storage media is discussed. Two successful methods of adapting common salt for this purpose are given.

References.

(1) Wiegand, E. H. "Walnut Drying and Packing in Oregon." Oregon Agr. Exp. Sta. Bull. 227 (1927).

(2) Wormald, H. and Harris, R. V. "Notes on certain plant diseases observed in 1931." E. Malling Res. Sta. Ann. Rep., 1931, 47.

(3) Hamond, J. B. "A Survey of the Walnut Position in England, 1932." E. Malling Res. Sta. Ann. Rep., 1932, 73-8.

* The writer is indebted to Mr. W. A. Roach for the suggestion that sodium phosphate might be combined with common salt, in order to counteract the moisture-absorbing properties of the latter. This deliquescence is mainly due to magnesium chloride which is present as an impurity in the salt. On addition of sodium phosphate this compound is converted into insoluble magnesium phosphate which is not deliquescent.

THE USE OF RUBBER STRIPS IN BUDDING FRUIT TREES*

By R. J. GARNER

It is the practice in American horticulture at the present time to use rubber instead of raffia when tying buds in the nursery. Some of the advantages claimed are that no constriction occurs in the region of the bud, as is so frequently the case when raffia ties are neglected, and no attention is required for the purposes of retying or removal of the tie. The quality of the rubber is adjusted to withstand climatic conditions for a number of weeks without breaking.

During 1932 nursery trials were started at East Malling Research Station to test the value of rubber as compared with raffia. Rubber budding-strips were obtained from British Columbia and from a source in England. Strips of similar quality were obtained from both sources varying in size from 4 to 6 ins. in length, and 3 to 5/16ths in width and capable of being stretched to a length of 3 ft. without breaking. Ten plots each containing twenty apple stocks were used to try out each method, the plots being arranged so as to eliminate the effect of soil differences. The rootstock used was No. IX Jaune de Metz and the whole 400 stocks were budded on the same day by the same person with the variety Cox's Orange Pippin.

Records were taken of cost and time taken in budding. The particular strips used at East Malling cost 5s. per 1,000 ties, but there appears to be no reason why the cost of these should not be reduced if larger quantities were required. Best raffia, including cost of pulling, approximated to 3s. 6d. per 1,000 ties. However, it should be borne in mind that raffia-tied buds often require retying, and in such cases the cost is doubled. Ninety-nine of the raffia ties needed retying owing to breakages which occurred at intervals during twenty-one days following budding. The average speed of tying was 111 ties per hour with rubber as against 126 ties per hour with raffia. In view of the fact that the tyer had never used rubber budding strips before, but was used to raffia, it appears that there was very little to choose between the two methods in regard to speed of the operation.

In May of this year (1933) records were taken of the condition of the buds. In this one trial the average success is 92 per cent. with rubber and 79 per cent. with raffia. It is realized that this is only the first trial under East Malling conditions, and in view of this it is unwise to jump to conclusions based on these figures. The trial is being repeated this year, and will be extended to other classes of hardy fruits as material becomes available. Suffice it to say that rubber appears to have been at least as useful as raffia for the purpose of tying inserted buds.

I should be glad to learn the experience of any who have used rubber strips either in budding or grafting.

* Reprinted from the *Gardeners' Chronicle* (1st July, 1933) by permission of the Editor.

OTHER PUBLICATIONS OF GENERAL INTEREST

THE following articles written by members of the Staff for various journals should prove of general interest to our readers :

" Cherry Stocks at East Malling. I. Stocks for Morello Cherries." N. H. Grubb. Journ. Pom. and Hort. Sci., December, 1933.

"'Free' or Seedling Rootstocks in Use for Pears." R. G. Hatton. Journ. of Pom. and Hort. Sci., December, 1933.

" The Planting of Apples." N. B. Bagenal. East Norfolk Fruitgrowers' Association Year Book, 1933.

" Towards an Agricultural Policy. Part IV. Section V. Fruit Farming." R. G. Hatton and N. B. Bagenal. Country Life, April, 1933.

" Heresy in the Cherry Orchard." N. B. Bagenal. H.E.A. Year Book, 1933.

" Mosaic Disease of the Raspberry in Great Britain. I. Symptoms and Varietal Susceptibility." R. V. Harris. Journ. Pom. and Hort. Sci., September, 1933.

" The Strawberry Yellow Edge Disease." R. V. Harris. Journ. Pom. and Hort. Sci., March, 1933.

" Strawberry Root Rot in England." G. H. Berkeley. Nature, October, 1933.

" The Raspberry and Loganberry Beetle and How to Control it." W. Steer, East Norfolk Fruitgrowers' Association Year Book, 1933.

PUBLICATIONS

LIST OF PUBLISHED REPORTS FOR THE YEAR COMMENCING 1ST JANUARY, 1933 TO 31ST DECEMBER, 1933.

	TITLE.	JOURNAL OF PUBLICATION.		REPRINTS.
	POMOLOGY.			
	TOP FRUITS.			
	Root Stocks.			
	Apples.			
E69.	Breeding Experiments with "Paradise" Apple Root Stocks. *H. M. Tydeman.*	Journ. of Pom. and Hort. Sci. (September, 1933.) No. 3.	**11.** 214-236.	Out of Print.
	Cherries.			
E64.	Cherry Stocks at East Malling. I. Stocks for Morello Cherries. *N. H. Grubb.*	Journ. of Pom. and Hort. Sci. (December, 1933.) No. 4.	**11.** 276-304.	Price 1s. 3d. Plus postage.
	Pears.			
E66.	"Free" or Seedling Rootstocks in Use for Pears: Their Description, Selection, Vegetative Propagation and Preliminary Testing. *R. G. Hatton.*	Journ. of Pom. and Hort. Sci. (December, 1933.) No. 4.	**11.** 305-333.	Price 3s. 5d. Plus postage.
	General.			
E59.	The Planting of Apples. *N. B. Bagenal.*	East Norfolk Fruit Growers' Association Year Book, 1933. (January.)	67-75.	No Reprints.
Eg5.	Towards an Agricultural Policy. Part IV, Section V. Fruit Farming. *R. G. Hatton and N. B. Bagenal.*	Country Life. (April, 1933.) No. 1891. ..	**73.** 381-383.	No Reprints.
E60.	Apple Variety Collection. *H. C. Chapelow.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.)	58-63.	No Reprints.
Eg6.	The Use of Rubber Strips in Budding Fruit Trees. *R. J. Garner.*	Gardeners' Chronicle. (1st July, 1933.) No. 2427.	**94.** 13-14.	No Reprints.
Eg4.	Scion Rooting at East Malling Research Station. *R. G. Hatton and N. B. Bagenal.*	Kent Farmers' Union Journal. (June, 1933.) No. 6.	**33.** 226.	Price 2d.
	Root Studies.			
E58.	Root Studies. III. Pear, Gooseberry and Black Currant Root Systems under Different Soil Fertility Conditions, with Some Observations on Root Stock and Scion Effect in Pears. *W. S. Rogers.*	Journ. of Pom. and Hort. Sci. (March, 1933.) No. 1.	**11.** 1-18.	Price 2s. 5d. Plus postage.
	Nuciculture.			
E62.	A Survey of the Walnut Position in England, 1932. *J. B. Hamond.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.)	73-78.	No Reprints.

TITLE.	JOURNAL OF PUBLICATION.	REPRINTS.
E67. Some Recent Investigations into Methods of Storing Walnuts during the Winter. *J. B. Hamond.*	Gardeners' Chronicle. (16th September, 1933.) No. 2438. .. .. .. **94.** 219-220.	Price 7d.
MISCELLANEOUS.		
E61. A Preliminary Irrigation Trial. *J. Amos, R. G. Hatton and A. C. Painter.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.) .. .. 64-67.	No Reprints.
SMALL FRUITS.		
GENERAL.		
Esf23. Cultivated Blackberries, Dewberries and Hybrid Berries. *A. B. Beakbane.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.) .. .. 68-72.	Out of Print.
Esf24. Some Notes on Loganberries and Blackberries. *A. B. Beakbane.*	Kent Cherry and Soft Fruit Show Catalogue. 1933. .. .. 17-22.	No Reprints.
BIOCHEMISTRY.		
MISCELLANEOUS.		
K7. The Distribution of Molybdenum. *W. A. Roach.*	Nature. (February, 1933.) .. .. **131.** 202.	No Reprints.
MYCOLOGY AND BACTERIOLOGY.		
APPLES.		
C86. Some Incidental Effects of Routine Scab-Sprays, with special reference to Apple Fruit Sawfly-Control—A Sidelight on the Interpretation of Field Spraying Experiments. *M. H. Moore.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.) .. .. 90-98.	Price 5d. Plus postage.
C93. Apples Should be Picked with their Stalks. *H. Wormald.*	Journ. of Min. of Agric. (October, 1933.) No. 7. .. .. **40.** 586-587.	No Reprints.
PEARS.		
C85. Spraying Trials against Pear Scab (*Venturia pirina*). Some Practical and Theoretical Aspects of the Interpretation of the Results. *M. H. Moore.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.) .. .. 99-108.	Price 3d. Plus postage.
C91. Spraying Experiments on the Control of Pear Scab at East Malling. *M. H. Moore.*	Journ. of Min. of Agric. (October, 1933.) No. 7. .. .. **40.** 111-119.	No Reprints.
RASPBERRIES.		
C87. The Infection of Raspberry Fruits by the Cane-Spot Fungus. *R. V. Harris.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.) .. .. 86-89.	Price 3d. Plus postage.

	TITLE.	JOURNAL OF PUBLICATION.		REPRINTS.
C88.	The Commercial Control of Raspberry Mosaic Disease. *R. V. Harris and N. H. Grubb.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.)	149-151.	Price 2d. Plus postage.
C92.	Mosaic Disease of the Raspberry in Great Britain. I. Symptoms and Varietal Susceptibility. *R. V. Harris.*	Journ. of Pom. and Hort. Sci. (September, 1933.) No. 3.	**11.** 237-255.	Price 2s. 4d. Plus postage.
	STRAWBERRIES.			
C84.	The Strawberry "Yellow-Edge" Disease. *R. V. Harris.*	Journ. of Pom. and Hort. Sci. (March, 1933.) No. 1.	**11.** 56-76.	Price 3s. Plus postage.
C70.	Strawberry Root Rot in England. *G. H. Berkeley.*	Nature. (October, 1933.)	**132.** 570.	No Reprints.
	MISCELLANEOUS.			
C89.	Notes on Plant Diseases in 1932. *H. Wormald and R. V. Harris.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.)	81-85.	No Reprints.
		Gardeners' Chronicle. (18th March, 1933.)	**93.** 192-193.	
		Gardeners' Chronicle. (25th March, 1933.)	**93.** 213.	
		Gardeners' Chronicle. (1st April, 1933.) ..	**93.** 228-229.	
C90.	Brown Rot Fungi: Recent Observations on Their Incidence. *H. Wormald.*	Fruit Grower. (17th August, 1933.) No. 1966.	**66.** 229-230.	No Reprints.
		Fruit Grower. (24th August, 1933.) No. 1967.	**66.** 259-260.	
	ENTOMOLOGY.			
	APPLES.			
D89.	Two Apple Capsid Spraying Trials and Some Notes on Spray Damage. *W. Steer.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.)	132-140.	No Reprints.
	RASPBERRIES AND LOGANBERRIES.			
D86.	The Raspberry and Loganberry Beetle and How to Control It. *W. Steer.*	East Norfolk Fruit Growers' Association Year Book, 1933. (January.)	85-87.	Gratis.
D85.	Studies on *Byturus tomentosus* Fabr. III. Further Experiments on its Control on Raspberries, Loganberries and Blackberries. *W. Steer.*	Journ. of Pom. and Hort. Sci. (March, 1933.) No. 1.	**11.** 19-38.	Price 1s. 6d. Plus postage.
	STRAWBERRIES.			
D87.	Further Observations on the Strawberry Tarsonemid Mite. *A. M. Massee.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.)	117-131.	Price 8d. Postage 2d.
	MISCELLANEOUS.			
D83.	*Tarsonemus approximatus* Banks, var. Narcissi Ewing: A Variety of Tarsonemid New to the British List. *A. M. Massee.*	Annals and Mag. of Nat. History. (February, 1933.) Ser. 10.	**11.** 198-201.	Price 2d.

	TITLE.	JOURNAL OF PUBLICATION.		REPRINTS.
D84.	A New Species of Gall Mite from South India. *A. M. Massee.*	Annals and Mag. of Nat. History. (February, 1933.) Ser. 10.	**11.** 201-203.	Price 2d.
D88.	Notes on Insect Pests and Mites in 1932. *A. M. Massee.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.)	109-116.	No Reprints.
	HOPS.			
B20.	Symptoms of Manurial Deficiencies in Hops. *F. H. Beard.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.)	156-158.	Price 3d.
B21.	Dungungsversuche zu Hopfen (The Manuring of Hops). *F. H. Beard.*	Die Phosphorsaure. (June, 1933.)	**3.** 372-382.	Few available.
B22.	Sixteenth Report on the Trial of New Varieties of Hops, 1932. *E. S. Salmon.*	East Malling Research Station, Kent. (July, 1933.)		Price 6d.
	MISCELLANEOUS.			
H16.	East Malling Research Station Supplementary Annual Report (20th year). General Development and Activities.	1st January, 1932 to 31st December, 1932. (May, 1933.)		Out of Print.
H18.	Weather Conditions during 1932. *H. C. Chapelow and H. M. Tydeman.*	East Malling Res. Sta. Ann. Rep. for 1932. (May, 1933.)	78-80.	No Reprints.
	ANNUAL REPORTS.			
A16.	Annual Report, 1932.	East Malling Research Station. (May, 1933.)		Price 3s. 6d. Post free.

To be obtained from:—

THE SECRETARY,

EAST MALLING RESEARCH STATION,

EAST MALLING,

KENT.